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HERPETOLOGICA

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Indications for the Hybrid Origin of *Bufo terrestris* Bonnaterre*

OTTYS SANDERS

An understanding of the interrelationship between species of *Bufo* in the United States can best be achieved by discussing them as a whole throughout the totality of their ranges rather than individually or from a particular area. Somewhat of an exception to this thesis, however, is provided by *Bufo terrestris* Bonnaterre, a species whose existence in the eastern United States I believe to be more fortuitous than that of its two neighboring species, the far-ranging *Bufo americanus* Holbrook and *Bufo fowleri* Hinckley. The territory which *Bufo terrestris* occupies, a coastal strip from the Carolinas to Louisiana, is both of circumscribed extent and restricted geographic nature. These facts have been used by those who see an interspecific relationship between *B. terrestris* and *B. americanus* (Netting & Goin:1946). The present paper proposes instead that *B. terrestris* is adapted to a coastal existence because the species had its origin in part from an island ancestor and that its geographic position is a consequence of spreading northward and southward from a central area, believed to be either the Florida peninsula or the adjacent mainland. A subspecific relationship between *B. americanus* and *B. terrestris* is questioned since the latter is thought to be an entity separate from other species of United States toads.

The hybrid origin of *B. terrestris* may explain its morphological similarity to both *Bufo americanus* and *Bufo fowleri. Bufo terrestris* completely disassociated from the range of either of the above species may have single, enlarged warts in small spots as in *Bufo americanus* or numerous smaller warts in enlarged spots as in *Bufo fowleri;* a pigmented venter as in *americanus* or unpigmented venter as in *fowleri;* divided subarticular tubercles of the 4th toe as in *americanus* or undivided subarticular tubercles of the 4th toe as in *fowleri.* A supratympanic ridge connecting the parotoid gland with the postorbital ridge is often thought of as showing morphological relationship between *B. americanus* and *B. ter-*

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restris, but this supratympanic ridge is more characteristic of Mexican than American species of *Bufo*. The separation of the parotoid gland from the postorbital ridge, typical of *americanus*, does not imply a connecting ridge between these two structures. None the less, in a broad manner, the morphological features of *B. terrestris* are like the combined attributes of *B. fowleri* and *B. americanus*, so that the species has a morphological anonymity except for an unique "cranial club" on its interorbital crests. The composition of this cranial club, however, appears to explain the origin of *B. terrestris* and opens up a wide vista of possible historical relationships.

In brief it may be said that the cranial club of *Bufo terrestris* is formed by a combination of skeletal structures peculiar to North American toads, fused with similar skeletal structures peculiar to Mexican and Central American toads. While heretofore, no separation has been made between the crania of toads from these respective areas, there are several features which make their distinction possible.

Comparison of the Mexican-Type and American-Type Skulls

For the sake of conciseness, Central American and Mexican species of *Bufo*, including some that extend into southwestern U. S., having as a common denominator the *occipital ridge*, will hereafter be referred to as Mexican species with the Mexican type skull. On the other hand, those species having a *parietal spur* only and largely confined to the United States and Canada, will be designated as American species with the American type skull.

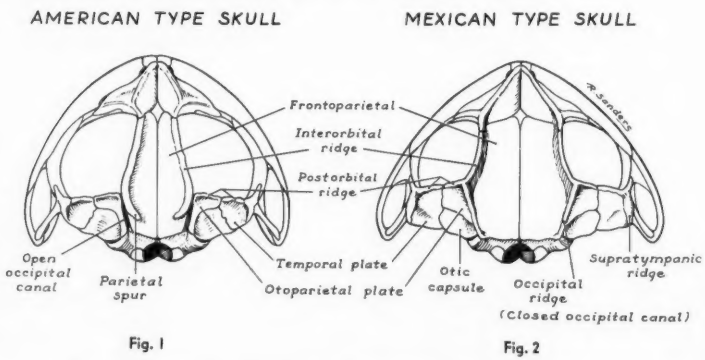

Fig. 1.—Schematic drawing of American-type bufonid skull.
Fig. 2.—Schematic drawing of Mexican-type bufonid skull.

The significance of the occipital ridge (Fig. 2) in Mexican species of *Bufo* has long been known and used in their taxonomy

(Kellogg:1932 = parietal crests; Smith & Taylor:1948). What has not been recognized, however, is that there exists in Mexican bufonids a basic combination of skeletal elements to make such a ridge, whether it rises sufficiently above the surface of the skull to be visible or not. The cranial element primarily involved is the *otoparietal plate* (Fig. 2), a structure so named because of its location between the otic capsule and the parietal part of the skull (Sanders:1953; p. 38). The size and shape of the otoparietal plate varies among bufonid species but the plate is much more extensively developed in the Mexican group. Anteriorly it completes a portion of the orbit, while posteriorly it may extend as an oblong rectangular piece over part of the otic capsule as in *Bufo marinus*, or be inserted as a fan-shaped piece at the postero-medial corner of the eye in *Bufo valliceps*. *An occipital ridge is formed by fusion of the medial border of the otoparietal plate with the lateral border of the frontoparietal in the occipital region.* If the edges of both are sharply upturned, a sharp ridge is produced as in *Bufo valliceps* and *Bufo mazatlanensis*; or the ridge may be rounded or flattened as in *Bufo marinus, B. gemmifer, B. marmoreus* and *B. compactilis*. Rather than coin additional terminology it seems desirable to describe the juncture of the otoparietal plate and frontoparietal as the occipital ridge or "occipital ridge area" whether a sharp ridge is produced or not. In some specimens and/or species a portion of the occipital ridge area may be ridged while another portion of the same area is flattened.

The otoparietal plate does not enter into the formation of the *parietal spur* in the American type skull (Fig. 1). In *Bufo americanus* the parietal spur has its lateral border confluent with that of the occiput; in *B. fowleri* the spur bends medially, leaving an open area between the border of the spur and the edge of the occiput.

In the American type skull, the otoparietal plate lies alongside and lateral to the open occipital groove. In the Mexican type, on the contrary, there may be little if any attachment to the occipital groove, the medial edge of the plate being either above and lateral to the groove, or overlapping the groove and joining with the frontoparietal more medially. The occipital ridge may or may not parallel the occipital groove, its course being determined by the size and shape of the otoparietal plate and by the extent of the frontoparietal postorbitally.

Intrusion of the frontoparietal into the postorbital area is another trait peculiar to the Mexican type. This intrusion causes a shift of the occipital ridge from an origin at the postero-medial corner of the eye as in *B. valliceps* to a more lateral position in *B. marmoreus* and *B. mazatlanensis*.

In the American type skull, the otoparietal plate is separated

from the occiput of the skull by an open longitudinal groove through which the occipital artery runs to the orbit. In the Mexican type skull, this artery with its channel is often roofed over or may be buried deeper in the area between the otic capsule and occiput, entering the skull through a foramen in the exoccipital. In other Mexican species, as exampled by *B. marinus*, the posterior portion of the occipital canal may be open because only the anterior part of the otoparietal plate joins with the frontoparietal. This frequently coincides, as it does in the example cited, with an extension of the plate into the orbital area to help form a bony cap at the postero-medial corner of the eye. In the American-type skull, the orbital portion of the otoparietal plate rarely if ever protrudes beyond the border of the otic capsule.

It is presumed that this bony cap affords protection to the optic nerve and adds support to the thin-walled orbit by extending its boundaries. Its formation also involves the *perpendicular lamina* of the orbit in a manner not observed in the American-type skull (Sanders:1953:37) where a postorbital wing of the lamina forms the back side of the orbital portion of the otoparietal plate. I do not agree with Baldauf (1958:176) that *Bufo valliceps* lacks the *perpendicular lamina*. In that species as in other Mexican type toads, the perpendicular lamina is in close apposition with the frontoparietal and gives off a postorbital wing which not only extends to the postero-medial corner of the eye as in the American type but then bends forward paraorbitally and coalesces with its

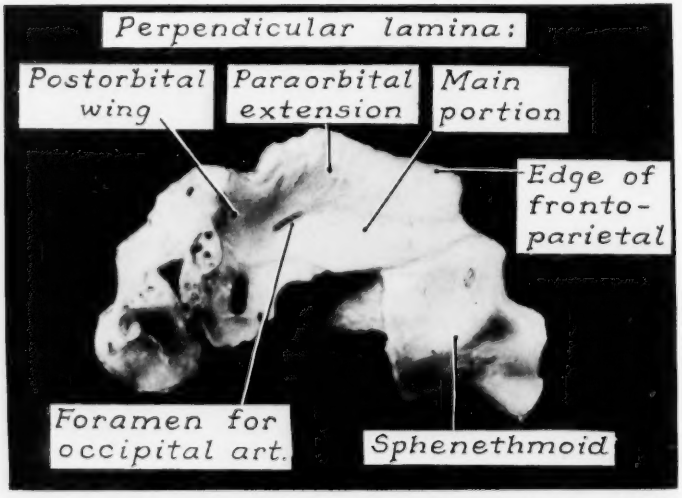

Fig. 3.—*Bufo valliceps*. Extension of perpendicular lamina paraorbitally.

main portion along the dorsal edge (Fig. 3). The forward-folding of the postorbital wing encloses the orifice through which the occipital artery enters the orbit. Baldauf (1958:181, 183) points out that in *B. valliceps* the frontoparietal is ankylosed to the prootic bone. While we are in agreement as to the ankylosis in this area, our interpretation is that the postorbital process of the perpendicular lamina is fused with the orbital prootic.

The degree of ossification in the two types of bufonid skull, while among the less tangible differences is probably of considerable import. In the Mexican-type skull there appears to be less ossification and of a different quality. The membrane bones are light and thin, the otic capsule appears to a large degree cartilaginous and dissolves readily in solutions of sodium hypochlorite. Baldauf (1958:183) confirms the lack of ossification in the otic capsule of *Bufo valliceps*. Along with its lightened bony construction, the Mexican type skull has very broad frontoparietals and a broad postorbital shelf, tending to make the head seem flattened.

In the American-type skull, there is greater ossification accompanied by a reduction in breadth and height of frontoparietals and reinforcement of their free edges with bony matter, as in the interorbital ridge of *B. americanus*. There is also reduction in breadth of the postorbital shelf and increase in depth of the otic capsule with its shortening and ossification. There is great reduction of the otoparietal plate so that it no longer forms a roof over the occipital canal or a cap at the corner of the eye. Coincident with this reduction of bony elements, the skull assumes a more heightened appearance.

Bufo terrestris, A Composite-Type Skull (Fig. 4)

The cranial club of *Bufo terrestris* combines the distinguishing structures we have noted in the American and Mexican type skulls. There is an enlarged parietal spur, typical of the American type, fused with a somewhat triangular otoparietal plate of the Mexican type at the corner of the eye. The plate's anterior face varies from lying almost horizontal to sloping vertically. Its median edge is fused with the parietal spur and forms the lateral side of the cranial club: its posterior edge is free above the occipital canal but joined to it by a ridge from the lateral bank of the canal. In specimens with the club not fully developed, a portion of the open canal is seen posteriorly, but in old specimens with large clubs, practically all the canal is covered and appears to have sunken lower so that the aperture for the occipital artery is in the top border of the exoccipital. The club is in fact a modified occipital ridge of short extent ,swollen by its apposition to the parietal spur.

This dual make-up of the cranial club is visible externally in many specimens, appearing sometimes as though a small piece had

been plastered to the side of the parietal spur, or in others showing a greater division between the two elements composing the club (Fig. 4). More commonly, this dualism of the club is concealed by its ornamentation with bony masses, which in skeletal preparations disclose a rounded coral-like aspect. An explanation of this may be in the co-ossification of skin with spongy bone, where, layer after layer, by the close fusion of the two, the structure has been built up. Not only has the fusion of skin and bone obscured or eliminated points of junction between the bony elements, but, where the junction was not sharp, it has tended to round-out the union.

Fig. 4.—Skulls of *Bufo terrestris* showing composite nature of cranial club. (Charleston Mus. 53.16.32:Kershaw Co., S. C.).

Care must be taken not to mistake the simulation of a parietal club for the actual prominence. Such imitations are frequently seen in individuals of *B. americanus*, far removed from the range of *B. terrestris*, wherein the parietal spur is somewhat enlarged, due usually to bony irregularities or anomalies. Irregularities in the parietal spur of *B. fowleri* also may be mistaken for clubs. Once the two elements responsible for the cranial club in *terrestris* are recognized, there should be fewer such errors.

Additional features of *B. terrestris* suggesting relationship to Mexican bufonids include its broad frontoparietals, its flattened and poorly ossified otic capsule, the supratympanic ridge between the parotoid gland and postorbital crest. This latter structure has been discussed previously. The broad frontoparietals give rise to high cranial ridges separated by a broad interorbital space, as in Mexican toads. These high cranial ridges reflect a difference between *terrestris* and *americanus* in the area where their ranges meet, for the high interorbital crests of *terrestris* extend above its postorbital crests at the postero-medial corner of the eye, while those of *americanus* do not. In *B. terrestris* the otic capsule and crista parotica form an oblong, bow-tie shaped, flattened postorbital shelf similar to that of other Mexican bufonids and unlike

the shorter and deeper postorbital areas in *B. americanus* and *B. fowleri.*

Upon this basic structure, however, are alterations, some belonging to the American type, others a retention of Mexican type traits, while a third group is composed of a combination of both types as demonstrated in the cranial club. The postorbital process of the perpendicular lamina of the orbit does not bend forward as it does in Mexican species, nor is it fused with the orbital prootic. A modified cap at the corner of the eye, however, is formed by the undersurface of the cranial club, involving the same elements which produce a cap in Mexican species, namely the otoparietal plate and frontoparietal. In most of the Mexican species of toads examined, except *B. marinus* and *B. compactilis,* the anterior end of the parasphenoid where it rests against the sphenethmoid is pen-shaped, coming to a point. In *B. terrestris* the end of the parasphenoid is blunt and ridged as it is in *B. americanus* and *B. fowleri.* While the skull is broadened by wide frontoparietals, it has a more erect position than that of flat-headed Mexican species such as *B. valliceps.* This difference in height is governed by the squamosal which shows an intermediacy between that of the American and Mexican types. The supratympanic ridge is an inherited structure to be associated with the Mexican type. The nature of this ridge has been discussed in greater detail in a previous paper (Sanders:1953:41-44). Structurally, therefore in *Bufo terrestris,* there is a commingling of two entirely different cranial types and the production of a new kind of bufonid skull with a distinctive new element, the cranial club.

The Mexican-Type Ancestor of *Bufo terrestris*

Since *Bufo terrestris* inhabits an extensive coastal area, it would seem that the process of building, consolidating and dispersing the species has been in progress over a long period of time. Assuming that *B. americanus* and *B. fowleri,* species which currently border its range and whose morphological features are reflected in those of *B. terrestris,* may have participated in molding the species, we need also to determine the ancestral Mexican prototype which has left evidence of its being in the structural makeup of the skull.

Origin from B. valliceps questioned.—Bufo valliceps, the Mexican species whose range meets that of *B. terrestris* in the Florida Parishes of Louisiana (Anderson et al. 1952: 274; Gandy, 1952) is the only Mexican bufonid whose range in current times approaches that of *B. terrestris.* The hybridization experiments of Volpe (1956:61-75) involving crosses between *B. valliceps* and *B. fowleri* produced a hybrid (1956:fig. 11) having some characteristics similar to those of *B. terrestris.* These are sharply diverging interorbital ridges which bound a triangular interorbital area;

a prominent supratympanic ridge between parotoid gland and postorbital crest, and a reticulated pigmentation of the venter. Similar crosses between *B. valliceps* and *B. americanus* were also made by Volpe (1959:336-340). However, in the hybrids produced by Volpe and in others obtained by Thornton (1955) involving *B. valliceps* and *B. woodhousei*, the one distinguishing earmark of *B. terrestris*, namely the cranial club, is not reproduced. It seems unlikely that the origin of *B. terrestris* can be attributed to hybridization between *B. valliceps* and these species, in view of the lack of morphological evidence, as well as the possibilities of hybrid sterility demonstrated in laboratory crosses.

While hybrids between *B. valliceps* and *B. fowleri* do not duplicate *B. terrestris*, they do indicate how certain morphological features of the latter may have originated. The cross between a small rectangular interorbital area (in *B. fowleri*) with a larger one (in *B. valliceps*) appears to have produced in Volpe's hybrid a triangular interorbital area of greater size than exists in *B. fowleri*. A sufficient sample of such hybrids should be examined to determine the expansible limits of such triangular areas in relation to the rectangular areas from which they originate, before deductions can be made as to the size of interorbital areas involved in forming that of *B. terrestris*. Since, however, the interorbital area of *terrestris* generally exceeds that of *fowleri* or *americanus*, it was probably derived from a toad species having as broad an interorbital area as does *B. valliceps* or a broader one. The interorbital ridges in Volpe's hybrids are high and sharp like those of *valliceps*. Similarly in *B. terrestris* the interorbital ridges are high and sharp, commonly rising above the level of the postorbital ridges where the two meet, while in *B. americanus* both ridges are generally of the same height (except in some populations from Minnesota and Illinois). From this one might surmise that ancestral *B. terrestris* had high interorbital ridges, probably exceeding their current height. According to Volpe, the *fowleri x valliceps* hybrid had parietals like *B. valliceps*, i. e. an occipital ridge. Since the club of *B. terrestris* is a modified occipital ridge, such a structure was certainly one of the attributes of its ancestral type. A similar affirmation may be made regarding the supratympanic ridge which is also a constant feature in *terrestris*.

All of the above traits of *B. terrestris*—broad interorbital space, high interorbital ridges, occipital ridge, supratympanic ridge—correspond to similar features in *B. valliceps*. They are not, however, peculiar to *B. valliceps* alone but rather are broad characters of Mexican and Central American bufonids which are variously modified in different species. It is not our intention to suggest that the particular species, *B. valliceps*, is the ancestral Mexican prototype of B. terrestris, but rather that it is representative of a

general group to which the ancestral form probably belonged.

The advance of *B. valliceps* overland to its present penetration of southeastern Louisiana east of the Mississippi River is believed to have been accomplished within recent times. The Mississippi River with its valley was likely a more formidable barrier during Pleistocene and post-Pleistocene times than it is today. The sparse distribution in eastern Louisiana and Mississippi of *B. valliceps,* a species which is such a rugged competitor west of the Mississippi River, suggests that it is only now gaining a foothold in that area. Probably the most convincing argument against origin of *terrestris* from *B. valliceps* is the absence of *B. terrestris* from that vast area west of the Mississippi River in Texas and Louisiana which is populated by *B. valliceps* and where both time and opportunity would have favored its origin from that species. Instead *B. houstonensis* and *B. w. velatus* likely reflect the course of speciation with *B. valliceps* as a participant.

Origin of the Species from Island Ancestors.—The geographic position and current range of *Bufo terrestris* are clues in themselves to the area of its inception. While we know little of the time required for a species to spread, an ability which likely is variable, indications from studies of home ranges suggest that it would have taken a very long time to colonize the coastal strip from Louisiana to Virginia now populated with *Bufo terrestris.* There is evidence that in the Carolinas, toward the northern boundary of the species, the invasion by *B. terrestris* has been recent because of the remaining small pockets of other toad species in the interior of otherwise consolidated populations of *terrestris.* Similarly, toward the southern boundaries of the range of *terrestris* in Louisiana the species becomes variable through genetic interchange with its neighbors as has been noted by Anderson et al, 1952; and by Volpe, 1958. This would seem to indicate that the center of distribution for the species lies between these two extremes. Florida, with its geological history, its intermediate location within the range of the species, and the population density of *B. terrestris* within its borders, is clearly pointed to as such a distribution center.

If one conceives of peninsular Florida and adjacent continental U. S. as the birthplace of the species, the door is opened to consideration of an island route through which an ancestral form of Central American origin may have reached this geographic location. That would be through the Greater Antillean Chain. Such a hypothesis has been suggested by Barbour (1930:74) for *Bufo quercicus,* a companionate species with *B. terrestris* throughout its range.

Both Schmidt (1928) and Darlington (1957) believe the fauna of the Greater Antilles to be derived from that of Central Amer-

ica. Schmidt (1928:13) in his study of the herpetofauna of Puerto Rico and the Virgin Islands, forms these conclusions among others: "1. That the Greater Antilles received their fauna from Central America at a time so early that the continental fauna has subsequently undergone great changes, probably in Eocene or even in Pre-Tertiary time. 2. That the Greater Antillean fauna gives us a somewhat obscure representation of this earlier Central American fauna, most of which, in accordance with Matthew's general hypothesis, has moved on to South America."

Darlington (1957:516-518) suggests that Central America itself was an island through at least a part of the Tertiary and that terrestrial vertebrates reached the Greater Antilles across salt water, with the more significant Antillean groups coming from Central America by way of Cuba. He concludes (1957:518) from the evidence gathered "that vertebrates have dispersed from continents onto fringing archipelagos, across water gaps, much more extensively and in some cases much farther than Wallace guessed."

If one envisages the bufonids of the Greater Antilles as coming from Central America through Cuba across salt-water gaps, the additional salt-water jump from Cuba to peninsular or insular Florida in early times becomes quite plausible. Once established in Florida, the forerunner of *Bufo terrestris* had ample opportunity for contact with and subsequent isolation from the continental fauna. Especially was this so as late as the Pleistocene period with its accompanying fluctuations of water level. (For Historical Biogeography of Present-Day Florida, see publications by Neill:1957; Duellman and Schwartz:1958; Goin:1958).

That a form suited to island existence might establish itself on the mainland in a coastal environment is indubitable. This process could be accelerated if the form integrated with the mainland fauna without being absorbed. Once established on the mainland, reintroduction to an island environment might favor growth or longevity without otherwise changing the species. This has been the course taken by *Bufo terrestris* on offshore islands. Giant size specimens from Cat Island off the Mississippi coast (reported by Smith and List:1955:117) do not differ materially from those of the mainland. Giants from Cumberland Island off the coast of Georgia (Charleston Museum No. 33.76.31) are similarly undistinguished as are those from Horn Island, Mississippi, which do not attain giant size. While giant *B. terrestris* probably are more common on some offshore islands, they are also found occasionally in peninsular Florida. Duellman and Schwartz (1958:253) and Riemer (1958:210) cite specimens from southern Florida. At the opposite extreme in size, Duellman and Schwartz (idem ref. p. 215) find populations of *B. terrestris* on Big Pine Key, off the southern tip of Florida, noticeably smaller than those of the mainland. The

only specimen which has been available to me for examination from Big Pine Key, a subadult tannish specimen (U. Mich. Mus. 108174) agrees in characteristics with similar clay-colored *terrestris* from northern Florida and its panhandle. All the evidence currently available, therefore, would imply that the island populations of *B. terrestris* as they exist today were derived from the mainland after the species had become established.

Our concern then, is with a more thorough knowledge of Central American and Mexican bufonids and their evolution from a type. That such a type introduced into the Greater Antillean Chain did not stop short of *insular* Florida and represents the Central American ancestor of *Bufo terrestris* would logically explain the structural peculiarities of that species. The skeletal evidence clearly indicates that *Bufo terrestris* is of hybrid origin.

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Southwestern Biological Supply Co., Dallas, Texas.

Experimental Crosses between *Rana aurora aurora* Baird and Girard and *Rana cascadae* Slater

KENNETH R. PORTER

The Red-legged frog, *Rana aurora aurora*, and the Cascade frog, *Rana cascadae*, are adjacent allopatric forms which occur in the Pacific Northwest and whose precise taxonomic status is questionable. These frogs were originally treated as separate species and more recently as conspecific subspecies.

The Red-legged frog was first described from the Puget Sound area in 1852 by Baird and Girard and has been recognized as a species from that time to the present. This frog is probably distributed over most of Oregon west of the Cascade Mountains and has

been collected from the locations indicated in Figure 1. Non-breeding Red-legged frogs are found in down timber, dense patches of vegetation and to some degree adjacent to ponds and small streams.

The Cascade frog was originally described as a new species, *Rana cascadae,* by James R. Slater (1939). A Check List of North American Amphibians And Reptiles, by Karl P. Schmidt (1953), treats this frog as a subspecies, *Rana aurora cascadae.* In his book, Amphibians of Western North America, Robert C. Stebbins (1951) also designates this form as *Rana aurora cascadae.* The type specmen is an adult female collected by Slater June 19, 1938, from the Elysian Fields, Rainier National Park, Washington, at an elevation of 5,700 feet. The Cascade frog is found chiefly in the higher montane regions of the Cascades and has been collected in Oregon as far south as Crater Lake; known collection localities are indicated in Figure 1.

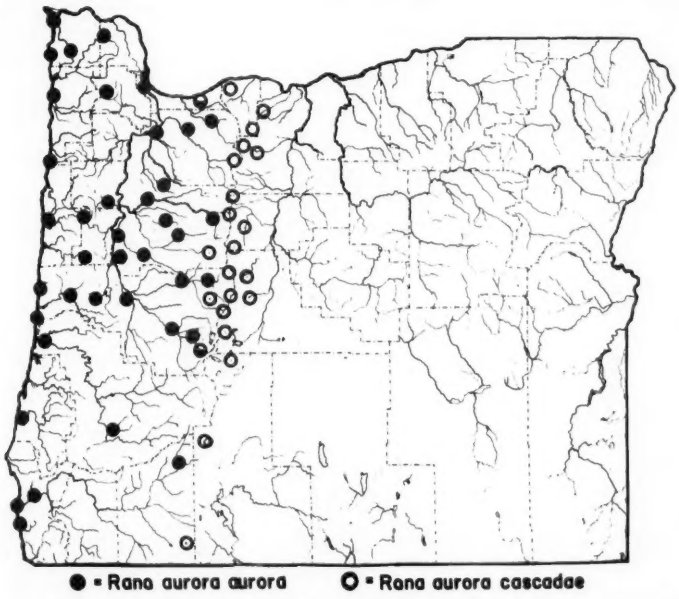

Fig. 1.—Locality records of the Red-legged and Cascade frogs in Oregon.

While the Cascade frog is generally found above the Transition Zone and the Red-legged frog is limited to lower elevations, being especially abundant in the valleys, their ranges do overlap to some degree in the Canadian Zone. Thus, they have essentially allopatric distributions characteristic of subspecies. However, Dunlap

(1955) observed no overlapping in ventral coloration and concluded no genetic interchange was taking place in these zones of contact. The result of Dunlap's morphological comparisons, plus this lack of intergradation, indicates that the two frogs should be treated as separate species.

Modern speciation studies have led to an acceptance of reproductive isolation as the primary criterion for specific distinctness. Richard G. Zweifel (1955) made a single cross between Red-legged and Cascade frogs and obtained abnormal embryos. He suggested that this single experiment indicated that a specific level of difference has been reached by these frogs but that confirmatory evidence in the form of more experimental crosses was desired.

The purpose of this study was, through a series of reciprocal crosses, to determine the degree of reproductive isolation between these two frogs in order to clarify their taxonomic relationship.

Methods and Materials

Adult Cascade frogs were collected during August and the first week of September from Wildcat Creek, Cedar Swamp, and Upper Horse Creek, all within the Three Sisters Wilderness Area, Lane County, Oregon; and from the meadows around Sparks Lake, Deschutes County, Oregon. A retention problem was created because the Cascade frogs had to be obtained prior to hibernation in September, and the Red-legged frogs were difficult to find until October and November when breeding migrations occurred. Therefore, after collection, the frogs were retained in large aquaria and kept in a temperature-controlled room at a temperature of 35°F. (1.7°C.). Approximately three inches of water were placed in the aquaria and then several inches of leaf litter were added which allowed the frogs to bury themselves in the material. This proved to be a very satisfactory method of holding the frogs with very little care being required at such a low temperature. Frogs were kept in this manner for as long as four months before induced ovulation was initiated. (One female Red-legged frog was held for a full year under these conditions and appeared to be healthy upon being released.)

Mature Red-legged frogs were collected from the following locations: Coffin Butte ponds, 10 miles north of Corvallis, Benton County, Oregon; a tributary of Champoeg Creek, approximately 2 miles southwest of Hubbard, Marion County, Oregon; in the vicinity of the Calapooya River west of Tangent, Linn County, Oregon; and from marshes near Florence, Lane County, Oregon.

The pituitary method (Rugh, 1948) was used to induce ovulation. After being injected the female frogs were kept at room temperature until ripe. Females which had become ripe were held quite successfully for a few days in a refrigerator at a temperature of

40°F. without any apparent effect upon the fertility of the eggs, if the females were allowed to warm to room temperature prior to ovulation. Thus, the eggs from several females could be fertilized at one time, resulting in a greater number of crosses per male than otherwise would have been possible. A parallel control from eggs and sperm of the same type was made for each of the crosses. The eggs were fertilized artificially for all cultures.

The first twenty-four cultures were kept in a temperature controlled room at a temperature of 68°F. (20.0°C.) while the last thirty-five cultures were kept at a temperature of 60°F. (15.5°C.).

Finger bowls were used for the culture containers and tenth-normal Holtfreter's solution was used for the culture medium throughout the study. None of the hybrid embryos hatched and, therefore, each experiment was terminated after all hybrid development had ceased and all developing control embryos had hatchd.

Records of development were based upon the maximum development attained by at least fifty per cent of the individuals of the culture, using the stages as outlined by Rugh (1948).

Results

A total of 1,653 eggs were treated with foreign sperm in the cross cultures and 1,674 eggs were treated with natural sperm in the parallel control cultures. The percentages of the eggs which were successfully fertilized and the percentages of fertilized eggs which developed to various embryonic stages are indicated in Table 1.

Cultures of cascadae Eggs

There was no significant difference in fertilization between the 790 *cascadae* eggs treated with *aurora* sperm and the 661 *cascadae* eggs which were treated with *cascadae* sperm, the percentages being as high as 100 per cent for both crosses and controls. There was only one culture in which none of the *cascadae* eggs was successfully fertilized. This particular culture was exposed to *aurora* sperm which successfully fertilized only 3 out of the 318 eggs to which it was applied. Therefore, the results from cultures involving this particular male *aurora* are considered to be attributable to a lack of viable sperm.

All *cascadae* eggs which were successfully fertilized developed through the late blastula stage with no apparent differences in structure or developmental rates between hybrids and controls. The first discernible abnormalities involving these crosses occurred during the process of gastrulation when many of the hybrids exhibited various degrees of exogastrulation. Although a considerable number of the hybrid gastrulae were deformed in this manner, the majority of them developed through the neural fold stage. It is interesting to note that in the cultures maintained at 60°F. there

Egg Source	Sperm Source		Number of Eggs	Fertilized No.	%	Gastrulae No.	%	Neural Fold No.	%	Tail Bud No.	%	Response No.	%	Hatched No.	%
		(1)	324	236	72.8	236	100	72	30.5	61	25.8	25	10.6	0	00.0
cascadae	aurora	(2)	466	445	95.5	445	100	402	90.3	85	19.1	39	08.8	0	00.0
		T	790	681	86.2	681	100	474	69.6	146	21.4	64	09.4	0	00.0
		(1)	249	244	98.0	244	100	229	93.9	213	86.9	181	74.2	139	57.0
cascadae	cascadae	(2)	412	329	79.9	329	100	329	100.0	268	81.5	179	54.4	69	21.0
		T	661	573	86.7	573	100	558	97.4	481	83.9	360	62.8	208	36.3
		(1)	157	137	87.3	124	90.5	00	00.0						
aurora	aurora	(2)	856	402	47.0	400	99.5	355	88.3	228	56.7	214	53.2	118	29.4
		T	1013	539	53.2	524	97.2	355	65.9	228	42.3	214	39.7	118	21.9
		(1)	161	45	28.0	9	20.0	00	00.0						
aurora	cascadae	(2)	702	23	03.3	19	82.6	12	52.2	1	04.3	00	00.0		
		T	863	68	07.9	28	41.2	12	17.6	1	01.5	00	00.0		

TABLE 1.—The total numbers and percentages of fertilization and extent of embryonic development as related to the two types of eggs and sperm and developmental temperature. (1) represents cultures maintained at 68°F.; (2) represents cultures maintained at 60°F.; and T represents the total for each type of cross. Percentage of development is based on number of eggs fertilized.

was a greater mortality between gastrulation and the formation of the neural folds than in the other eight cultures of hybrids from *cascadae* eggs which were maintained at 68°F.

The cultures of hybrids derived from *cascadae* eggs which were kept at a temperature of 68°F. exhibited a greater increase in mortality between the neural fold stage and the tail bud stage than did the cultures which were kept at a temperature of 60°F. Those individuals which survived to the tail bud stage appeared to be normal in development of the anterior regions, whereas the posterior regions were abnormal in many individuals due to an incomplete incorporation of the yolk material. The posterior disorders resulted in the tail developing at approximately a forty-five degree angle to the longitudinal axis of the body. The presence of internal disorders is suggested by the fact that none of the developing hybrids hatched, although from external appearance several appeared to be quite normal at the muscular response stage.

Cultures of aurora Eggs

In all the reciprocal crosses, in which *aurora* eggs were used, the percentage of eggs successfully fertilized was much lower than that for the *cascadae* eggs. There was a significant difference between the fertilization rates of the control cultures and that of the cross cultures. Although only 53 per cent of the *aurora* eggs which were treated with *aurora* sperm were fertilized, a very low average of about 7 per cent of those treated with *cascadae* sperm were fertilized.

Abnormalities were evident in the cross cultures from the first cleavage stages on through later development. Many of the eggs which had appeared to have been fertilized failed to cleave and those which did cleave were quite variable in their cleavage rates. Less than one half of the *aurora* eggs which were fertilized by *cascadae* sperm developed to the gastrula stage. Many mortalities occurred in the late blastula stages of the hybrid embryos. At the same age the control embryos were beginning to gastrulate.

None of the cultures of *aurora* eggs which were maintained at 68°F. developed beyond the gastrula stage so this series of crosses was repeated at a temperature of 60°F.. The same abnormalities occurred in the hybrid cultures maintained at this temperature as had occurred previously at the warmer temperature. Again, the development of the hybrids lagged behind that of the control embryos. Twelve of the developing hybrids survived to the neural fold stage and one of these continued to develop to the tail bud stage after which it died. As embryos were successfully reared through hatching in each of the cultures of controls at this temperature no further crosses were made.

Summary of Results

The total fertilization and extent of development of the fertilized eggs from each type of female are indicated in Table 1. The hybrid embryos derived from *cascadae* eggs incurred the highest mortalities after the neural fold stage, whereas the hybrid embryos derived from *aurora* eggs showed the greatest increase in mortality prior to the gastrulation process.

It was obvious that some of the sperm suspensions, especially those from two *aurora* males, were quite dilute or inviable. It was also apparent these particular *cascadae* eggs were more readily fertilized than the *aurora* eggs as evidenced by the results of fertilization attempts with sperm from five *aurora* males which fertilized 100 per cent of the *cascadae* eggs as opposed to smaller percentages of the *aurora* eggs which were fertilized in the corresponding control cultures. Temperature effects undoubtedly partially account for the relatively poor success of *aurora* control embryos.

The development of *aurora* eggs was greater at a temperature of 60°F. than at a temperature of 68°F.. On the other hand, the development of hybrids from *cascadae* eggs was greater at 68°F. than at 60°F..

Discussion

The results of these experimental crosses indicate that an intrinsic reproductive isolating mechanism, characteristic of species, prevents the Red-legged and Cascade frogs from interbreeding.

The Red-legged and Cascade frogs are ecologically distinct forms. The Cascade frog occurs principally in the upper elevations of the Cascade Mountains of Washington, Oregon, and California and in the Olympic Mountains of Washington. It is found at higher elevations than the Red-legged frog which occurs at lower elevations west of the crest of the Cascade Mountains of southern British Columbia, Washington, Oregon, and northern California.

Slater (1939) describes the Cascade frog as being typically a Hudsonian frog in the Canadian Zone. The Cascade frog is the only *Rana* which Slater (1939) finds in the Hudsonian Zone of Washington. The author and others have found the Oregon distribution of the Cascade frog to be primarily in the Hudsonian, Canadian, and Upper Transition Zones of the Cascades while the Red-legged frog is confined to the Transition Zone, being most abundant in the lower elevations. Stebbins (1954) states that the Cascade frog is principally in the Boreal Zone (commonly the Hudsonian Zone) but that it is found as low as the Upper Transition Zone. He also notes that it is found at higher elevations than *aurora* which is found down to the upper portions of the Lower Sonoran Life-Zone in California. Thus, these two forms have a consistent altitudinal re-

lationship to one another with a limited overlap of their ranges within the Transition Zone.

The habitat preferences of the Red-legged and Cascade frogs are also quite different. Except during the breeding season when they migrate to ponds, adult Red-legged frogs are found most commonly among downed logs, ferns, blackberry thickets, and dense understory types of vegetation. They may often be found in damp situations quite some distance from the nearest body of water. The Red-legged frog population at the Coffin Butte ponds, north of Corvallis, was the only exception to this habitat preference noted by the author. Here the frogs were found in the immediate vicinity of the ponds only and apparently spend a considerable amount of time actually in the water. There is very little vegetative cover around these ponds and the surrounding area is quite arid, being rather a barren southern exposure. Therefore, the close relationship of these frogs to the ponds is almost a necessity for the survival of this population. Dunlap (1955) also found that these Coffin Butte frogs departed to the greatest extent from the general habitat type characteristic of Red-legged frogs.

In contrast to the Red-legged frog, the Cascade frog is found most commonly in close proximity to small streams and sub-alpine meadow potholes, being rarely more than a few yards from permanent bodies of water. These frogs appear to prefer stream banks that are covered with grass, ferns, or other types of low herbaceous vegetation.

The breeding season of the Cascade frog is from the latter part of May to July, while that of the Red-legged frog is from the the middle of January until March. This difference undoubtedly arose as a result of physiological adaptations to the two different climatic conditions which prevail at the respective altitudes. Snow depth is probably a very important factor affecting the initiation of the breeding activity of the Cascade frog, as pointed out by Slater (1939). Night temperatures and precipitation seem to be the primary factors which stimulate sexual activity in Red-legged frog populations.

The eggs of *aurora* are deposited in relatively deep and cool ponds while those of *cascadae* are deposited in the shallows of deep pools or in shallow ponds that are, consequently, warmer during the day and much of the night. Therefore, although the Cascade frog is found at higher elevations, its embryonic development is undoubtedly adapted to warmer temperatures than that of the lowland form. The experimental results of this study indicate that the optimum temperature for development of *aurora* eggs is less than 60°F. while that for *cascadae* eggs would appear to be in the vicinity of 68°F..

The masses of *aurora* eggs are compact and ovoid in contrast to the more flattened *cascadae* egg masses. In addition, the *cascadae* egg masses are deposited at or near the surface of the water while those of *aurora* are attached to vegetation at greater depths. Both of these characteristics of *cascadae* egg masses are interpreted as adaptations to warmer water and lowered oxygen tensions, as discussed by Moore (1940).

On the basis of morphology, *cascadae* frogs can readily be distinguished from *aurora*. Adult morphological characteristics which distinguish *cascadae* from *aurora* have been described by Dunlap (1955). It is very significant that Dunlap could find no instance where individuals showed an overlap or intergradation of morphological characteristics. It was noted by the author that the *cascadae* tadpoles were generally a darker shade of brown dorsally than the *aurora* tadpoles. The *cascadae* tadpoles also tend to have a more blunt tail fin than that of the *aurora* tadpole which is pointed.

Conclusion

On the basis of the experimental crosses made in this study plus the single cross made by Zweifel (1955) it is apparent that *Rana cascadae* and *Rana aurora* are reproductively isolated and incapable of interbreeding with one another. Zweifel used the subspecies *Rana aurora draytoni* and was able to get several hybrids to hatch. This subspecies is geographically isolated from *Rana cascadae*. In these crosses involving the subspecies *R. aurora aurora*, whose range has a limited overlap with that of *R. cascadae*, no hybrids hatched. This suggests reinforcement of the intrinsic isolating mechanism through selection for hybrid inviability in the two forms that come together.

The morphological studies of Dunlap (1955) and observations by the author and others leave no doubt as to the morphological distinctness of *R. cascadae* and *R. aurora*. Ecological and physiological differences between these forms have been established. In view of this evidence it is concluded that the Red-legged and Cascade frogs meet all of the specifications required of biological species and should, therefore, be separate species, designated as *Rana aurora* Baird and Girard and *Rana cascadae* Slater.

Acknowledgements

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gon State College were always willing to loan equipment and make facilities available. Dr. D. G. Humphrey of the General Science Department, Oregon State College, and fellow graduate students in the Zoology Department were especially helpful in the collection of animals. Locality records of the Red-legged and Cascade frogs in Oregon were obtained from Robert M. Storm and from records in the Oregon State College Museum of Natural History.

Summary

The purpose of this study was, through experimental crosses, to determine if a reproductive isolating mechanism exists which would prevent *Rana aurora aurora* and *Rana aurora cascadae* from interbreeding. The presence of such a reproductive isolation mechanism would indicate that a specific level of differentiation had been reached by these frogs.

A series of reciprocal crosses has been made under laboratory conditions, using the pituitary technique to induce ovulation and employing artificial fertilization. Parallel controls were established for each cross. The results of the crosses are consistent with those of other interspecific hybridization studies. None of the hybrids hatched, indicating the presence of an intrinsic reproductive isolating mechanism between these two forms. On the basis of this evidence plus ecological, ethological, and morphological differences it is concluded that the Red-legged and Cascade frogs meet the specifications for species and should be designated as *Rana aurora* Baird and Girard and *Rana cascadae* Slater.

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The Taxonomic Position of *Natrix sipedon insularum* Conant and Clay

J. William Cliburn

Natrix sipedon insularum was described by Conant and Clay (1937) from an aberrant adult population of *sipedon* occupying islands in the western part of Lake Erie. As diagnosed by these investigators, *N. s. insularum* is similar in size and scutellation to *N. s. sipedon*, from which it differs in the complete, or almost complete, absence of dorsal and ventral color pattern. The pattern tends to be uniformly gray above and cream white below. Conant and Clay studied 669 specimens, most of which were alive, and concluded that this pattern is present from the time of birth, and does not change during development.

According to Conant and Clay, and later reporters (Camin, Triplehorn, and Walter, 1954; Camin and Ehrlich, 1958), specimens showing intergradation with *sipedon* are present on all the islands. This is to be expected, as the distances between the various islands and the mainland are four miles or less; Camin and other biologists frequently saw snakes swimming several miles from the nearest shore. The describers recognized that random crossings occurred occasionally, and pointed out that the farther an island is from the mainland, the less contamination by *sipedon* is evident. On some of the islands, specimens which are indistinguishable from *sipedon* occur in small numbers. Intergrades or specimens showing *insularum* characteristics are uncommon on the Ohio mainland, and absent from the Ontario mainland.

Conant and Clay recognized the imperfection of the narrow fresh water barrier surrounding the islands, but considered it sufficient to prevent the absorption of *insularum* by *sipedon*.

Percentages of typical *insularum*, based on numbers sufficient to be reliable, ranged from 27.5 per cent to 61.1 per cent on various islands. When intergrade percentages were added to the above, the numbers ranged from 43.7 per cent to 94.4 per cent.

Camin, Triplehorn, and Walter (1954) studied 254 specimens and concluded that a much higher percentage of specimens with typical *insularum* color pattern survives to maturity than do forms approaching typical *sipedon* in pattern. They suggested that predation, perhaps by the herring gull or other birds, may retard or prevent the establishment of the mainland snake, *sipedon*, on the islands, and the resultant survival of *insularum*.

In a later paper (Camin and Ehrlich, 1958), the frequencies of the various pattern types in new born litters were compared with those from among adult populations, and in one case with those from a group of juveniles. A rough interpretation of the histograms

in this report indicates that the percentage of *insularum* patterns in litters is only 10 per cent in the Bass Islands, and approximately 30 per cent in the Middle Island litters. In each case respectively, intergrades are around 12 per cent and 20 per cent. Among adults from the Bass Islands, there are around 35 per cent with typical *insularum* patterns, with another 35 per cent intergrades. Middle Island adults are about 65 per cent *insularum* types, with about 15 per cent intergrades. Middle Island juveniles show around 40 per cent with *insularum* pattern.

In all cases where the percentages of various pattern types were compared, there is a significant increase in the appearance of *insularum* patterns among adults in comparison with new born litters, and in comparison with juveniles.

In seeking possible explanations for this phenomenon, Camin and Ehrlich considered a number of possibilities. The occurrence of unbanded pattern types in litters, and the evidence which indicates no change in pattern of individual snakes during ontogeny, seem to eliminate the possibility that environmental conditions on the islands may have induced purely phenotypic changes in these snakes.

The maintenance of the unbanded types in the islands might be explained by migration of the form into the islands from elsewhere, but there is no known source of these migrants. The extreme abundance of the snakes on the islands, and the trend toward the unbanded condition on all the islands suggest a systematic selective pressure rather than random genetic drift.

By elimination of all these explanations, natural selection alone can account for the presence of populations with a high proportion of unbanded individuals on the islands. This selection is believed to be due to predation by herring gulls, herons, raptors, and man. The *insularum* type of coloration is believed to afford a degree of concealment not shared by the *sipedon* type, with the result that adult populations contain a significantly higher percentage of unbanded individuals than do the litters. The establishment of populations composed of 100 per cent unbanded individuals is prevented by the steady influx of banded migrants from the mainland.

Referring now to the above discussion, it is noted that the subspecies *insularum* is based on populations in which the highest percentage of the typical form is 65 per cent. This figure is rather low to merit subspecific recognition. If intergrade specimens are included, and they apparently were in the type description, the percentage rises considerably, but there is dubious wisdom in basing a subspecies upon intergrades.

Figures based on percentages in the new born litters seem to

be more useful, since they give a view of the genetic composition of the natural population before selection and migration. In these groups, the highest occurrence of the typical *insularum* pattern is only about 30 per cent.

It must be emphasized that the islands on which the *insularum* form occurs are not effectively isolated from the mainland. It is apparent from the figures discussed above, from the narrow "barrier" of fresh water surrounding the islands, and from the active swimming abilities of the snakes as observed, that there is constant exchange of individuals between mainland and islands, and the *insularum* form throughout its limited range is sympatric with *sipedon*. Certainly there is no reproductive isolation involved in this case. In the absence of isolation mechanisms of any observable sort, it is difficult to acknowledge *insularum* as deserving recognition as a distinct subspecies. At best, we may refer to *insularum* as an incipient subsepcies which is unable to establish itself because of the lack of isolation.

The problems involving the Lake Erie snakes are interesting, and deserve continued observation and study. The population represents at least a potential subspecies which might evolve if isolation were more complete, or which might be swamped by mainland types in the absence of effective predation.

Meanwhile, it seems best not to consider *Natrix sipedon insularum* as a valid subspecies, and to place the name in the synonomy of *Natrix sipedon sipedon*.

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The New Zealand Lizard Names *Naultinus* and *Hoplodactylus*

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Chrapliwy, Smith and Grant (1961, Herpetologica, 17:5-12) have recently transferred the well known gecko name *Naultinus* Gray from one New Zealand genus to another. This is the kind of confusing and valueless name shift that particularly exasperates general zoologists and is deplored even by some systematists, especially those (in this instance, the numerous New Zealand zoologists) to whom the animals concerned are well known members of the local fauna. For a number of reasons, I do not accept a goodly part of the still unpublished new Hemmingian Code (see Myers, Copeia, 1961:118) but I have examined the name-shift under discussion with some care to see if it is really necessary under traditional nomenclatural procedure, or under the new Code as I recall it from participation in the London Colloquium of 1958, where it was extensively revised.

I feel that there is considerable call to preserve nomenclatural stability where the animals concerned, and their names, have been well known to a large body of naturalists for a long time. On the other hand, when the zoological entities concerned are relatively obscure, when their names have rarely been mentioned in handbooks or in the general zoological literature, and when almost the only use that has been made of the names is by a few specialists, there is relatively little call to exert one's self to avoid changes that are clearly and incontestably indicated by nomenclatural rules. In the present instance, the names concerned are very well known to the numerous zoologists of New Zealand, and the shift would be a nomenclatural calamity. Moreover, as I intend to demonstrate, the action of Chrapliwy, Smith and Grant does not seem to be unquestionably supported by any rules.

Shift of the name *Naultinus* from the genus typified by *elegans* Gray, 1842, to the genus generally known as *Hoplodactylus* hinges upon two articles published by John Edward Gray in his own personally conducted publication-organ, "Zoological Miscellany," in 1842. Both papers occurred in the same signature of the Miscellany and therefore must have been published at exactly the same time. The date given on the first page of the 16-page signature is May, 1842.

In the pre-Hemmingian Rules (see 1926, Proc. Biol. Soc. Washington, 39:75-103), which I at present follow, there is nothing to force one to consider in a different manner names that were published in different articles by the same author in the same publica-

tion at the same date. In the new Rules, on the contrary, I believe that there is such a provision, although I am not sure that it applies to the case under consideration. To anticipate my conclusions, under the old Rules *Naultinus* can easily be considered to have been correctly applied in its traditional sense, and the shift proposed by Chrapliwy, Smith and Grant is unnecessary. On the other hand, if Messrs. Chrapliwy, Smith and Grant follow the Hemmingian Code, the shift is at best only doubtfully supportable by rules not yet available in definitive form to the zoological public.

John Edward Gray, although hallowed as the indefatigable builder and mentor of the Zoological Department of the British Museum, was, in his systematic work, a thoroughly unsystematic and erratic man. One has only to check his papers on Chelonia and Crocodilia to see how thoroughly he fouled up the classification and nomenclature of those groups. His treatment of the generic names *Sphenodon* and *Hatteria*, and of *Naultinus*, in the "Zoological Miscellany," is quite in character.

In the pertinent signature of that journal (I hesitate to call it a magazine, journal, or serial, for it was merely a series of printed signatures gotten out by Gray to expedite publication of his own papers and those of a few of his close colleagues) Gray published, among other things, the two articles under discussion. In the first (p. 58) he inserted, *without the generic heading that he habitually used for new genera*, the description of "*Naultinus pacificus* Gray," from "the South Sea Islands." Towards the end of the same signature, he published the second article, containing the description of the new genus *Naultinus*, and the description of *N. elegans* Gray, together with a statement that there is a second species in the British Museum, *N. pacifica* (which, of course, he had described a few pages earlier).

Under the old Rules I find nothing to prevent the interpretation that Gray published, at the same date, and, indeed, in the same signature of the same publication, a new genus *Naultinus*, in which he clearly included two new species, *N. pacificus* and *N. elegans*, neither being indicated as the type species of the genus. That he happened to insert the description of one species a few pages before the generic description in the same signature means nothing (except haste, eccentricity, or carelessness) *and the application of the name Naultinus to one or the other of the two presently recognized genera represented by the two included species depends solely upon the first subsequent designation of a type species for Naultinus!*

If the type of *Naultinus* was not determined by the removal of one of the two species of a two-species genus (the principle of Opinion 6) by Boulenger (1885, Cat. Liz. Brit. Mus., 1:168) or some other author, then it was by the definite statement of Mal-

colm Smith (1933, Rec. Ind. Mus., 35:13) and McCann (1955, Domin. Mus. Bull. no. 17:28). In either case, the type species of *Naultinus* is *N. elegans* Gray and the shift proposed by Chrapliwy, Smith and Grant is needless.

Parenthetically, it should be pointed out that Gray's brief original description of *N. pacificus* is somewhat expanded by Gray (1843, in Dieffenbach, Travels in New Zealand, 2:203) where he refers the species to *Platydactylus duvaucelii* Duméril and Bibron, 1836, a fact not mentioned by Chrapliwy, Smith and Grant. It should also be noted that these authors, in common with others, have apparently overlooked the fact that Fitzinger, in his 1843 work, definitely designated generic type species of genera treated by him, by listing single species under a special column heading, "Typus." Therefore *Platydactylus duvaucelii* is the type of *Hoplodactylus* by definite original designation, not merely by monotypy, as Chrapliwy, Smith and Grant state.

If, however, the new Rules are followed, I am still not sure that the fact that Gray published his two species of *Naultinus* in two separate articles is meaningful. As of the Copenhagen Congress, the separate consideration of different papers published on the same date in the same journal seems to apply only to cases coming under Article 28; that is, cases having to do with the selection of one generic name when two of the same date are united —the "First Reviser Principle." It is not mentioned under Article 30, which deals with the type species of genera, which is the subject with which we are dealing. The new Rules, as totally revised at the London Colloquium in 1958, and as subsequently edited to avoid contradictory passages, have not been published, to my knowledge, at the date I write.

However, let us consider for a moment the apparent publication of the two originally included species of *Naultinus* in different "articles." If the wording of the new Rules follows that of the Copenhagen Decisions, the point hinges upon the meaning of the term "different publications." Are the articles in "Zoological Miscellany" *different publications* or are they not? Viewed in one way they are "different articles," but is that what is meant? As already mentioned "Zoological Miscellany" was not a magazine, journal, or serial in the commonly adopted sense. It was issued by Gray primarily to publish his own contributions, although he did include some articles by friends dealing with collections in which Gray happened to have an interest. Its sections appeared by signatures, which often ended in the midst of a paper, and no separate title pages (or covers?) for these "issues" were provided. Viewed in one way, the entire "Miscellany" was *one publication* by Gray, issued in parts, with most of the chapters (or divisions, or articles) by Gray, but with a few of them written by others. Cer-

tainly it can be argued that each signature was but one "publication." In a book, even in one issued by signatures, and containing some chapters by men other than the principal author, I think no one would argue that species described by the principal author in different chapters appeared in the "different publications," provided the pertinent chapters were published on the same date. I view the "Zoological Miscellany" in this latter light, which I believe to be reason enough for non-acceptance of the conclusions of Chrapliwy, Smith and Grant on *Naultinus*, even under the new Code.

I conclude that the name *Naultinus* Gray, 1842, type species *Naultinus elegans* Gray, 1842, by subsequent designation of Malcolm Smith, 1933, and of McCann, 1955, is applicable in its traditional sense; that it is not a senior synonym of *Hoplodactylus* Fitzinger, 1843 (type species by original designation *Platydactylus duvaucelii* Dumeril and Bibron, 1836); and that these two generic names of New Zealand lizards are to be accepted in their traditional sense. *Naultinulus* of Chrapliwy, Smith and Grant is therefore an objective (absolute) synonym of *Naultinus*.

It is to be noted that Chrapliwy, Smith and Grant appear to violate one of the niceties of precise nomenclatural practice by proposing *Naultinulus* as a "*nomen novum*." In the general sense, all newly proposed generic (and specific) names are *nomina nova*, and we could label every new genus "*nomen novum*." However, it has become conventional practice to use the term *nomen novum* only when proposing a substitute name, that is, a name to replace (substitute for) another name that is unusable through preoccupation. If Chrapliwy, Smith and Grant's conclusions in regard to the application of *Naultinus* were to be accepted, the zoological genus traditionally called *Naultinus* would be nameless, therefore without an available name for which another could be substituted. Under such conditions, the obviously precise nomenclatural course is to name and describe a *new genus* (*genus novum, nec nomen novum*) together with a designation of type species of the new genus.

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Habitat and Food of Mousetrapped Young *Rana pipiens* and *Rana clamitans*

JOHN O. WHITAKER, JR.

During the summer of 1959 and the spring of 1960 an area approximately four miles northeast of Ithaca, New York, was trapped in connection with a study of the meadow jumping mouse, *Zapus hudsonius* (Zimmerman). This area was divided into 1600 square plots, each of 745 square yards. Of these, 160 were chosen for trapping in 1959 and 120 in 1960 by means of a random numbers table.

Five rows of five traps were set in each plot at five yard intervals, with five yards between each row. Each plot was trapped for six consecutive days, and only once during the study. Dates trapped, general character of habitat, plant species, cover, distance from the plot to a body of water, and vertebrates taken were recorded for each plot. The study extended from May 29 to September 29, 1959, and from April 30 to June 21, 1960. During the summer of 1959 all swamps, marshes, and all but the deepest of the ponds dried up and were trapped, but in 1960, because of higher water, only 78 plots could be trapped.

The study area was nearly level, and included 11 small ponds, as well as several marshes, and numerous small swales. There was one large swamp extending diagonally across the area, several small swamps, many dry open fields, with widely dispersed brushy thickets and many hedgerows. Dry and damp woods were also present. Some of the dominant plants were *Carex, Scirpus, Eleocharis* and *Typha* in the marshes; *Fraxinus nigra, Acer rubrum* and *Ulmus americana* in the swamps; *Acer, Fraxinus, Fagus,* and *Rhus toxicodendron* in the woods; *Viburnum dentatum, Cornus racemosa,* and *Prunus* in the thickets and hedgerows; and *Solidago, Trifolium, Phleum pratense, Poa compressa,* and *Anthoxanthum odoratum* in the fields. *Leerzia oryzoides* and *Echinochloa* became dominant in the ponds and marshes as they dried up.

In addition to mammals, 130 young *Rana pipiens pipiens* Scherber and 40 young *Rana clamitans melanota* Rafinesque were caught, all but three of each species being taken in 1959. As numerous frogs were seen in the area in midsummer of 1960, it is believed that the paucity of frogs in traps that year was due to the early part of the year in which the area was trapped, rather than to a reduced population. Ryan (1953) reported that *Rana pipiens* transformed at 20 to 30.5 mm. at Ithaca, and some grew 22 mm. the first year, while *Rana clamitans* transformed at 26 to 38 mm. and attained a maximum length of 58 mm. the first year.

Frogs examined during this study ranged from 27 to 58 mm. in length (means of 39.1 in *R. pipiens*, and 46.6 in *R. clamitans*), thus it would seem probable that most transformed during the summer of 1959.

Although the study included 35,700 trap-nights, 174 frogs seemed to be an exceptionally large number to have been caught in mouse traps. This number was probably due to the excellent habitat afforded by the many ponds and marshes. Since traps were baited with peanut butter, it is doubtful that the frogs were attracted to the bait. It seems most likely that they were after slugs and ants, both of which were common on the bait. Nearly one third of the frogs taken had eaten ants, and some had eaten slugs. It is also possible that some frogs wandered into the traps.

TABLE 1.—Stomach contents of 95 young *Rana pipiens* from Ithaca, N.Y.

Food	% Freq.	% Vol.	Food	% Freq.	% Vol.
Insect larvae, mostly Lepidoptera	38.9	15.4	Muscoidea	8.4	3.0
			Syrphidae	1.0	0.8
Unidentified animal matter	28.4	10.0	Culicidae	1.0	0.2
			Mycetophilidae	1.0	trace
Vegetable matter	37.8	8.9	Unidentified Diptera	6.3	0.7
Snails	28.4	8.8	HEMIPTERA		(5.8)
Oniscidae (sowbugs)	18.9	4.0	Cicadellidae	25.2	3.6
Araneae (spiders)	12.6	3.3	Pentatomidae	2.1	0.4
Limacidae (slugs)	7.3	3.0	Nabidae	1.0	0.3
Chilopoda	1.0	0.7	Membracidae	1.0	0.3
COLEOPTERA		(12.6)	Neididae	1.0	0.1
Curculionidae	18.9	3.4	Miridae	3.1	0.1
Carabidae	7.3	2.5	Aphididae	3.1	0.1
Staphylinidae	8.4	2.2	Reduviidae	2.1	0.1
Chrysomelidae	3.3	1.0	Cercopidae	1.0	0.1
Cantheridae	1.0	0.4	Unidentified		
Silphidae	1.0	0.3	Hemiptera	6.3	0.9
Coccinelidae	1.0	0.2	HYMENOPTERA		(5.8)
Elateridae	1.0	0.1	Formicidae	28.4	4.0
Unidentified			Vespidae	1.0	0.4
Coleoptera	11.5	2.6	Tenthredinidae	2.1	0.4
ORTHOPTERA		(10.7)	Ichneumonidae	4.2	0.2
Acrididae	11.5	6.9	Unidentified		
Tettigoniidae	6.3	2.7	Hymenoptera	7.3	0.8
Gryllidae	2.1	0.9	Lepidoptera (adult)	6.3	3.8
Raphidophoridae	1.0	0.1	Odonata	1.0	0.4
DIPTERA		(6.5)			———
Tipulidae	2.1	1.8			99.9

Stomach contents of 95 *Rana pipiens* from the study area are summarized in Table 1. A great variety of animal foods are represented, probably because the diet of *R. pipiens* is governed by availability rather than by preference. Nearly anything of appropriate size that moves is probably eaten, thus an analysis such as this may be as much an indication of the presence and relative abundance of small animals in the area as it is of the food habits of the frogs. Because only 31 stomachs of *Rana clamitans* were examined they are not tabulated. However the food in this smali sample did not seem to differ radically from food in the *R. pipiens* stomachs. For example, insect larvae made up 20.3% of the volume in *R. clamitans*, snails 3.5%, slugs 2.3%, Coleoptera 16.0%, Diptera 9.5%, Hymenoptera 7.5%, Orthoptera 7.1%, Hemiptera 1.8%, and Lepidoptera 0.2%. In addition, one *R. clamitans* contained a crayfish and one contained a young *Hyla versicolor*.

Knowlton (1944) found freshly cast frog skins in six of 91 stomachs of *R. pipiens* from Ohio. On the other hand Kilby (1945), after examination of 443 stomachs, came to the conclusion that *R. pipiens sphenocephala* near Gainsville, Florida do not ingest their shed skins. I found no shed skins in stomachs during this study. The vegetable material found was probably ingested incidentally while feeding.

Other studies on the food of *R. pipiens* are: Force (1925), Drake (1914), Knowlton (1944), Kilby (1945), and Moore and Strickland (1954). Hamilton (1948) studied the food habits of *Rana clamitans*.

TABLE 2.—Habitats of *Rana pipiens* and *R. clamitans* (1959).

		Rana pipiens		*Rana clamitans*	
			No./100		No./100
Habitat	Trap-nights	No.	trap-nights	No.	trap-nights
Swamp	3900	8	0.21	15	0.38
Marsh and pond edge	2550	53	2.08	16	0.63
Open field	8700	43	0.49	2	0.02
Brushy field	3450	8	0.23	0	0.00
Woods	3300	11	0.33	4	0.12
Recently cut fields	2100	4	0.19	0	0.00
Totals	24000	127		37	

The number of frogs taken in each monthly period during the season was tabulated, considering only those habitats yielding appreciable numbers of frogs. Apparently the young of both species of frogs began transforming, or at least moving out from the water in numbers during the first half of July. During May, in 4700 trap-nights, only two *R. pipiens* (0.04 per 100 trap-nights), and no *R. clamitans* were taken. Comparable figures for June in

6800 trap-nights were two *R. pipiens* (0.03) and two *R. clamitans* (0.03). However, in July, in 3025 trap-nights, 44 *R. pipiens* (1.45), and 14 *R. clamitans* (0.46) were taken. This was the month when most frogs were present or otherwise susceptible to trapping, at least in the terrestrial habitat. In August, in 6850 trap-nights, 47 *R. pipiens* (0.69) and only three *R. clamitans* (0.04) were taken, representing a marked reduction, especially for *R. clamitans*. Further reductions occurred in September, when 11 *R. pipiens* (0.35) and one *R. clamitans* (0.03) were taken in 3150 trap-nights.

Apparently frogs moved into the terrestrial habitats in the study area in numbers in July, after which an abrupt decrease occurred in *R. clamitans*, and a gradual decrease in *R. pipiens*. Some possible reasons for the decrease might be that frogs moved back to the water, that predation reduced the numbers of frogs, or that some change in their behavior or feeding habits made them less susceptible to trapping. No evidence is available on the basis of this study to support or reject any of these possibilities. These data may be compared to those of Ryan (1953) who found that at Ithaca the majority of *R. clamitans* transform at the end of June and in the first week in July, and that most *R. pipiens* are transformed by the last week in July. Wright and Wright (1949) state that tadpoles of *R. pipiens* transform in July and that tadpoles of *R. clamitans* transform from April to September.

In considering habitat, marsh and pond edge were tabulated together because they were so closely related, one very often grading into the other. Recently-cut-fields consisted of oats (*Avena sativa*), and timothy (*Phleum pratense*) that had been cut and the new growth had reached a height of three to six inches. Frogs per 100 trap-nights, taken in the various habitats are given in Table 2.

Marshy areas and pond edges yielded by far the greatest proportion of *R. pipiens*, followed by open field. The other habitats all yielded lower numbers. Only two habitats had appreciable numbers of *R. clamitans*, swamp, and marsh and pond edge. Of these the latter again had the higher proportion. Thus, as might be expected, marshy areas and pond edges yielded the highest number of frogs. *Rana pipiens* apparently was more common than *R. clamitans* in all habitats except swamp. The catch of both species seemed somewhat high in woods. However, plots in woods where frogs were taken were very close to swamps.

Of the 17 marsh and pond plots, nine were associated with swamps. These plots yielded 30 *R. pipiens* (2.22 per 100 trap-nights) and 15 *R. clamitans* (1.11). The seven plots not closely connected with swampy areas yielded 23 *R. pipiens*, and only one *R. clamitans* (2.19 and 0.09 per 100 trap-nights). It would appear from this and from the fact that the swamp was the second most

productive area for *R. clamitans*, while open field was the second most productive area for *R. pipiens*, that in the study area *R. pipiens* inhabited an ecological niche including grassy areas or swampy areas surrounding ponds and marshes, while *R. clamitans* inhabited ponds and marshes, especially those associated with swamps. The habitats of the two species did broadly overlap however, and considering the study as a whole, using a chi-square test ,there was no significant negative correlation between the two species at the 95 percent level. This was due to the broad contact zone around ponds and marshes, and in swamps.

TABLE 3.—Relationship of *R. pipiens* and *R. clamitans* to cover (1959).

		Rana pipiens		*Rana clamitans*	
			No./100		No./100
Cover	Trap-nights	No.	trap-nights	No.	trap-nights
Good	4350	60	1.38	16	0.37
Fair	10500	53	0.50	12	0.11
Poor	9150	14	0.15	9	0.10
Totals	24000	127		37	

TABLE 4.—Distance to water of trapped *Rana pipiens* and *R. clamitans*.

		Rana pipiens		*Rana clamitans*	
			No./100		No./100
Distance to water	Trap-nights	No.	trap-nights	No.	trap-nights
0-20 yards	10050	90	0.90	33	0.33
21-40	2850	9	0.32	—	—
41-60	2700	12	0.44	—	—
61-80	900	1	0.11	—	—
81-160	21000	—	—	—	—
Totals	18600	112		33	

Ground cover in each plot was recorded as follows:

Good. Ground 100 percent covered by vegetation, dense. A mouse or frog would not be visible from above.

Fair. Ground incompletely covered by vegetation, or less dense. A mouse or frog could find hiding places, but would not be able to move freely without being seen from above.

Poor. Little vegetation, or the vegetation very thin. A mouse or frog would have great difficulty moving about without being seen from above.

The number of frogs associated with each cover group, expressed in number per 100 trap-nights is given in Table 3. More *Rana pipiens* were taken in plots with better cover (significant at the 99 percent level, using a chi-square test). The same was true

for *R. clamitans*, but was less marked (significant at the 95, but not at the 99 percent level). Martof (1953) found that smaller *R. clamitans* preferred dense vegetation. Kilby (1945) found that the largest populations of *Rana pipiens sphenocephala* were found where vegetation was the most luxurious. He believed that cover and food abundance were the responsible factors.

The distance of plots from water and the number of frogs taken per 100 trap-nights in 1959 are summarized in Table 4. All habitats except woods, and recently cut fields are included. Most of these water areas were dry at the time of trapping. All *Rana clamitans* were taken within 20 yards of the ponds or swamps. The greatest proportion of the *R. pipiens* were also taken within 20 yards, few being taken beyond 60 yards, and none beyond 80 yards. (Plots in this latter category ranged from 80 to 160 yards from water.

It was thought that rain might influence the activity of frogs, thereby affecting the number taken. Weather data from the Caldwell Field Weather Station, about three miles from the study area were used. These data should at least give a rough idea of the general effects of rain on the frog population. The July to September data of 1959 were used, and only for the habitats in which appreciable numbers of frogs were taken. Fifty-two *R. pipiens* were taken in 5550 trap-nights when rain occurred (0.94 frogs per 100 trap-nights), and 50 in 7475 trap-nights when no rain occurred (0.67 per 100 trap-nights). Apparently *Rana clamitans* is affected by rainy weather in roughly the same way, ten being taken on rainy days (0.18), and eight on dry days (0.12 per 100 trap-nights.) Thus both species seemed somewhat more active during rainy weather. Enough samples were taken in all weather in each habitat to minimize the effect of rainfall relevant to the other conclusions.

The apparent relation of frogs to the factors discussed above might conceivably be due to some difference in behavior of the frogs depending on whether the trap was in the open, in woods, etc.; or to a difference in the distribution of ants or other organisms on which the frog might be preying. Such did not seem to be the case, however, as frogs were taken commonly in both open and wooded areas; ants seemed to be common on traps throughout the area; and in general frogs were most commonly seen in those areas where frogs were most commonly taken in traps.

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Late Cenozoic Glass Lizards (*Ophisaurus*) from the Southern Great Plains

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Fossil glass lizards of the genus *Ophisaurus* (family Anguidae) have been reported from various Pleistocene and Pliocene localities in Florida (Auffenburg 1955, Holman 1958 and 1959) and from the Pleistocene of Oklahoma (Etheridge 1960a). Additional fossils of this genus are now available from one Pliocene and two Pleistocene localities in southwestern Kansas. All published records and those reported here are referable to one or another of the three modern species of North American *Ophisaurus*.

GENERIC IDENTIFICATION

There are no clear-cut differences between the body vertebrae of *Ophisaurus* and those of other North American lizards. Their identification must be made on the basis of a combination of characters: their broad, low neural spine which extends forward as a thin mid-dorsal fin, the very flat ventral surface of the centrum and their short, wide proportions.

The irregular distal extremities of the sacral diapophyses and the absence of articular surfaces at these extremities distinguish the sacral vetrebrae of *Ophisaurus* from those of all limbed North American lizards. The sacral vertebrae of *Ophisaurus* are similar to those of *Anniella* but differ in having much higher neural spines. Vertebrae of the sacral region in *Rhineura* are not differentiated as such.

The caudal vertebrae of *Ophisaurus* are similar to those of *Gerr-*

honotus and other anguids in that the transverse processes are separated into converging anterior and posterior portions by the autotomy septum. They differ, however, from all limbed North American genera in having the haemal arches fused to the centrum without a trace of suture. The haemal arches of limbed North American lizards are intercentrally located, though they may articulate with paired projecting facets at the ventral posterior border of the centrum. The haemal arches are also fused to the centra in *Anniella* and *Rhineura*. The caudal vertebrae of *Ophisaurus* differ from those of *Rhineura* in that the latter do not bear neural spines and are not autotomic. The caudal vertebrae of *Anniella* resemble those of *Ophisaurus* but differ in their much smaller size and much lower neural spine.

Specific Identification

Several osteological characters that can be used to diagnose the three modern species of North American *Ophisaurus* have been described by Auffenburg (1955) and Etheridge (1960a). These features, together with some additional diagnostic characters may be summarized as follows: The ratio obtained by dividing the length of the centrum of the body vertebra as measured from the greatest depth of the glenoid cavity to the most posterior extent of the condyle by the least width of the vertebra (actually the neural arch, not "centrum" of Auffenburg) may be used to distinguish the body vertebrae of *O. compressus* from *O. ventralis* and *O. attenuatus*, but not the latter two from each other. These ratios are: *O. compressus* 1.50 to 2.00 (mean 1.72), *O. ventralis* 1.12 to 1.55 (mean 1.36) and *O. attenuatus* 1.10 to 1.40 (mean 1.23). (The ratios given at the bottom of Auffenburg's Figure 1. are typographical errors and should read 1.1, 1.2, 1.3 - - - 2.0) The angle between the posterior border of the neural spine and the longitudinal axis of the centrum of body vertebrae may be used to distinguish *O. attenuatus* from *O. ventralis* and *O. compressus*. These angles are *O. attenuatus* 45° to 65° (mean 58°), *O. ventralis* 65° to 84° (mean 73°) and *O. compressus* 78° to 91° (mean 89°). The angle between the anterior border of the caudal transverse processes and the longitudinal axis of the centrum will diagnose the caudal vertebrae of all three species. These angles are *O. ventralis* 70° to 75° (mean 73°), *O. attenuatus* 75° to 85° (mean 81°) and *O. compressus* 50° to 65° (mean 55°). Structural differences will also serve to diagnose the caudal vertebrae of all three species. The caudal vertebrae of *O. ventralis* and *O. attenuatus* bear a short, vertical secondary neural spine above the plane of fracture. The secondary neural spine and fracture plane are absent in *O. compressus*. The caudal transverse processes are stouter in *O. attenuatus* than in *O. compressus* or *O. ventralis*.

On the basis of the diagnostic characters described above, all fossil vertebrae of *Ophisaurus* from the southern Great Plains are referrable to *Ohpisaurus attenuatus*. There appear to be no differences in size, proportions or structure between fossils from different deposits of the same or different ages or among those from the same deposit. All of these fossils are in The University of Michigan Museum of Paleontology (UMMP).

Fossil Localities

Jinglebob Local Fauna.—This fauna is referred to the later part of the Sangamon Interglacial of the Pleistocene by Hibbard and Taylor (1960). It is known from one locality in the SW¼, Sec. 32, T. 33 S., R. 29 W., Meade, County, Kansas. The vertebrate remains in this fauna imply a regional climate different from that of today. The summers were cooler, without the present-day extremes of heat and drouth; winters were milder, as warm as those of coastal Virginia today. Precipitation was much greater than that now falling locally. Pine pollen suggests an annual rainfall of 40 to 50 inches (Hibbard and Taylor *supra cit*). *Ophisaurus attenuatus* is represented in this fauna by five body vertebrae (UMMP Nos. 31834 and 43905), one sacral vertebra (UMMP No. 43907) and two caudal vertebrae (UMMP Nos. 35835 and 43906). Other lizards in the fauna are *Eumeces* sp., *Sceloporus* sp. and *Holbrookia* sp. (Tihen 1954).

Mt. Scott Local Fauna.—This fauna is referred to the late Illinoian Glacial of the Pleistocene by Hibbard (*in litt*). It is known from the base of Mt. Scott on the Big Springs Ranch in SE¼, Sec. 18, T. 32 S., R. 28 W., Meade County, Kansas. The vertebrate remains from this fauna imply cooler summers but probably warmer winters than now occur in that area (Hibbard *in litt*). One body vertebra (UMMP No. 43902) and two caudal vertebrae (UMMP Nos. 41238 and 43793) are the only fossil lizards yet discovered from this fauna.

Doby Springs Local Fauna.—This fauna is referred to the Illinoian Glacial of the Pleistocene by Stephens (1960). It is known from the N½, SW¼, Sec. 10, T. 27 N., R. 24 W., Harper County, Oklahoma. The fauna lived in an area surrounded by marsh and meadow vegetation with dryer uplands nearby. The climate differed from that of Harper County today in being generally cooler with greater effective moisture. The climate was similar to that of southeastern North Dakota today (Stephens *supra cit*). A single caudal vertebra (UMMP No. 40600) of *Ophisaurus attenuatus* is the only lizard remains from the fauna. I have elsewhere reported this vertebra (Etheridge 1960a).

Rexroad Local Fauna.—This fauna is referred to the late Upper Pliocene by Hibbard (1954). The fauna is known from a number

SERIES	NORTH AMERICAN AGES	PLEISTOCENE AGES	LOCAL FAUNAS	
			SW KANSAS	NW OKLAHOMA
PLEISTOCENE	RANCHOLABREAN	WISCONSIN Glacial	JONES Δ	
		SANGAMON Interglacial	JINGLEBOB O CRAGIN QUARRY ⊗	
		ILLINOIAN Glacial	MT. SCOTT O BUTLER SPRING Δ	DOBY SPRINGS O, BERENDS Δ
	IRVING-TONIAN	YARMOUTH Interglacial	BORCHERS ⊕	
	BLANCAN	KANSAN Glacial	CUDAHY ⊗ SEGERS Δ	CUDAHY ⊗ SEGERS Δ
		AFTONIAN Interglacial	SANDERS ⊗ DEER PARK Δ	
		NEBRASKAN Glacial	DIXON Δ	
PLIOCENE			BENDERS □ REXROAD (Wendell Fox Loc.) O SAW ROCK CANYON ⊗	
	HEMPHILLIAN			BUIS RANCH ⊗

LEGEND

- O Fauna containing Ophisaurus
- ⊗ Studied faunas containing no Ophisaurus
- ⊕ Lizards unstudied
- Δ Fauna containing no lizards
- □ Molluscan fauna

Fig.1.—Summary of late Cenozoic faunas from southwestern Kansas and northwestern Oklahoma.

of localities but the *Ophisaurus* fossils have been found only in the Wendell Fox Pasture, south side of Shorts Creek, SW¼, SW¼, Sec. 33, T. 33 S., R. 29 W., Meade County, Kansas (Woodburn 1961). The general appearance of the Rexroad landscape was probably much like it is today but with less topographic relief. The region was predominantly grasslands, perhaps with more timber along the streams. Periods of hot dry weather during the summer were less extreme and the mean annual precipitation was somewhat greater than today. Winters were considerably warmer than now: if temperature ever fell below freezing it did not remain so long (Hibbard 1960). *Ophisaurus attenuatus* is represented in this fauna by nine body vertebrae (UMMP No. 41305), nine autotomic caudal vertebrae (UMMP No. 41331), five pre-autotomic caudal vertebrae (UMMP No. 43903), one sacral vertebra (UMMP No. 38741) and one dentary (UMMP No. 43904). Other lizards in this fauna are *Cnemidophorus bilobatus, Cnemidophorus sexlineatus, Eumeces striatulus, Phrynosoma cornutum* and *Sceloporus robustus* (Taylor 1941, Twente 1952, Oelrich 1954, Etheridge 1960b).

Paleoecological Implications

A summary of late Cenozoic faunas from southwestern Kansas and northwestern Oklahoma is given in Figure 1. One or more faunas are now available from each glacial and interglacial age of the Pleistocene and from the Middle and Upper Pliocene in this area. All faunas from Pliocene deposits and from Pleistocene interglacial deposits contain lizards. Lizard remains are abundant in most of these faunas and include *Eumeces, Ophisaurus, Cnemidophorus* and a number of iguanid genera. Pleistocene glacial deposits, however, have yielded only occasional lizard fossils, either *Eumeces* or *Ophisaurus*, or none at all. Thus, *Ophisaurus* appears to be one of the few lizards that was capable of inhabiting the southern Great Plains during glacial periods of the Pleistocene.

The fossil localities from which *Ophisaurus attenuatus* have been taken in the southern Great Plains are some distance west of the present western limit of this species (Figure 2.). The species now extends over a wide latitudinal range, from central Wisconsin to southern Texas. Thus, the extreme winter minima and summer maxima found in southwestern Kansas and northwestern Oklahoma today are probably not the important factors limiting the present western distribution of this species. The presence of fossil *Ophisaurus attenuatus* in these areas may, however, indicate more mesic paleoclimates during the periods in which they occurred there, for the present climate is somewhat dryer than anywhere within the modern range of the species. The paleoclimates postulated for those fossil faunas on the basis of other animals also indicate more precipitation than these areas receive today. The Cragin Quarry

deposits from the Sangamon Interglacial of Meade County, Kansas contain the only lizard fauna from the southern Great Plains that implies climatic conditions as dry, or dryer, than occur there today (Etheridge 1958 and 1960c). The absence of *Ophisaurus* among the several hundred lizard fossils recovered from these deposits may be explained by the arid climate of Cragin Quarry times.

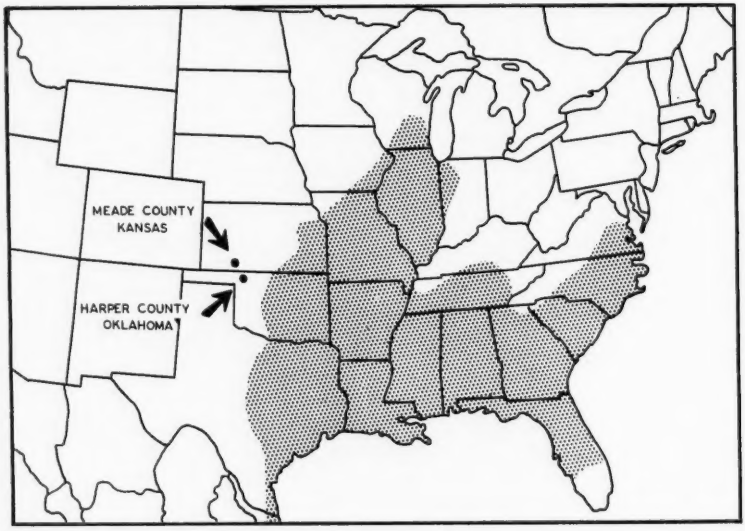

Fig. 2.—Localities from which fossil *Ophisaurus attenuatus* have been taken are indicated in southwestern Kansas and northwestern Oklahoma. These localities are west of the present range of this species, indicated by the stippled area.

Phylogenetic Implications

Fossil *Ophisaurus attenuatus* is, as yet, known only from the southern Great Plains. *Ophisaurus ventralis* has been reported from several localities in Florida: the Illinoian Glacial of the Pleistocene in Levy County (Holman 1959), the Wisconsin Glacial of the Pleistocene in Citrus County (Holman 1958), from Pleistocene deposits of unassigned age in Alachua and Marion Counties and from the Pliocene of Alachua County (Auffenburg 1955). *Ophisaurus compressus* has been reported from the Pleistocene of Alachua County, Florida (Auffenburg *supra cit*). On the basis of his fossils, Auffenburg has suggested the probability that 1) at least two groups, representing *attenuatus* and *ventralis*, were established before or during the Pliocene, or, 2) the ancestral form of North American glass lizards is very similar to *O. ventralis*. The presence of

Pliocene and Pleistocene *O. attenuatus* clearly supports the first of these suggestions. The second suggestion might also be true, for the two are not mutually exclusive; however, there are, at present, no morphological or paleontological reasons to consider either species similar to the ancestral type. The absence of palatine teeth in eastern *O. attenuatus* is certainly a specialization, but palatine teeth are present in the western subspecies. *Ophisaurus compressus* appears to be specialized in the tendency toward loss of autotomic planes of fracture, and may be considered somewhat removed from the ancestral type.

I have elsewhere indicated (Etheridge 1960a) that McConkey's (1954) hypothetical phylogenetic history of North American glass lizards is not tenable in view of the fossils available.

Acknowledgements

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Light Microscopy of the Blood Cells of Pseudemyd Turtles

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Although light microscope data for turtle blood cells are available (Jordan and Flippin, 1913; Charipper and Davis, 1932; McCauley, 1953), they are contradictory. The present study reevaluates the cells with the light microscope so that cytologic findings, e.g., electron micrographs, can be more readily compared. Also this is the first time that all the cells have been differentiated, fully classified, sizes measured, and counts made for the genus *Pseudemys*.

MATERIAL AND METHODS

The nembutalized adult turtle, *Pseudemys scripta elegans*, of 7-8 inch shell length was used. Because temperature and starvation can affect the properties of the blood (Musacchia and Rapatz, 1955), and thus indirectly of its cells, 110 animals were kept at room temperature and fed, and 50 turtles were used from this group.

Heparinized blood was drawn from the ventricle of the heart, exposed with an electric drill and hole saw.

Smears for cell types, morphology, and differential counts were made with Giemsa's stain, Wright's stain, and Brilliant Vital Red stain. The vital stain and unstained material were used to find whether the cell had motility.

Total counts for erthrocytes and leucocytes were made in isotonic saline solution since conventional diluents damage the cells. At least four counts were made per animal in a total group of twenty animals.

The sizes of cells and their inclusions (Table 1) were determined at 980 X with an ocular micrometer on unstained preparations. Cell shapes were determined in stained and unstained smears. Where stains are used, size and shape are sensitively bound to osmotic pressure. Isotonicity in the major stain used seemed to be achieved by adding 1 ml. of Giemsa's stock solution to 50 ml. of 0.55% sodium chloride solution. The cells were stained about 45 minutes and washed in water.

Experimental Data

All quantitative data on cell counts and sizes are listed in Table 1. The red cell, eosinophil, basophil, heterophil and thrombocyte drawn to scale in Giemsa-stained smears are illustrated in Figure 1. The lymphocyte and monocyte are drawn in vital-stained smears. Descriptive data are presented below, and are based chiefly upon Giemsa's stain.

Table 1.—Quantitative characteristics of the blood cells in *Pseudemys scripta elegans*.

Cell type	Cell dimensions in microns	Nuclear dimensions in microns	Granule dimensions in microns	Differential count in per cent*
	Mean ± S.D.	M ± S.D.	M ± S.D.	M ± S.D. (Range)
Erythrocyte	20.5 1.3 × 12.7 2.0	5.2 0.7 × 5.2 0.7	0.5 for largest granule	—
Heterophil (neutrophil)	10.61 0.51 × 10.61 0.51	8.36 0.94 × 8.36 0.94	2.54 0.38 × 0.38 —	10.1± 3.6 (5-14)
Eosinophil	10.4 1.0 × 10.4 1.0	8.23 0.81 × 8.23 0.81	1.57 0.39 × 1.57 0.39	12.4±12.0 (2-33)
Basophil (mast cell)	6.81 0.45 × 6.81 0.45	4.16 0.58 × 4.16 0.58	0.44 0.06 × 0.44 0.06	36.9±10.9 (25-53)
Lymphocyte	6.7 1.4 × 6.7 1.4	4.66 0.94 × 4.66 0.94	No granules	14.4± 5.2 (10-23)
Monocyte	11.8 1.6 × 11.8 1.6	6.5 1.3 × 6.5 1.3	No granules	24.1±12.1 (2-37)
Thrombocyte (spindle cell)	15.1 2.4 × 6.35 0.93	9.65 1.10 × 4.74 0.71	No granules	2.1± 2.1 (1-5)

*Total average count per c.mm. is 453,860 (192,200-667,700) for red cells and 16,140 (2,800-33,300) for white cells.

The circulating blood of several specimens of *Chrysemys picta* was also examined so that some generalizations might be drawn.

Red cell.—This cell is large and oval. Its surface membrane is smooth but indistinct.

The cytoplasm is pale and stains from neutral to slightly acidophilic. It is homogenous in consistency and contains few internal inclusions. The most constant of these is a fairly large globular body (Table 1) that lies close to the nucleus. Additional smaller, round inclusions are often seen.

The nucleus is strongly basophilic, i.e., deeply blue. It is typically round and its limiting membrane is smooth. In some cells the nucleus is fairly large and relatively homogenous. In other cells the nucleus is relatively small and seems to contain highly condensed nucleoprotein which varies in its configuration among the cells. There are other nuclei, intermediate in size; Jordan and Flippin (1913) describe these as growth or dengenerative stages. Mitotic figures are not seen in the circulating red or white cells.

Lymphocyte.—This essentially resembles the human lymphocyte. It is spheroidal and is the smallest cell of the blood.

The cytoplasmic matrix, which is visible as a circular peripheral band, is slightly acidophilic in Wright's stain and colorless in Giemsa's stain. Polychromatic granules are seen in the matrix with vital staining. Many vacuoles of different sizes, shapes and staining reactions are present.

The nucleus is round and occupies most of the cell. In vital staining there is no sharp contrast between the nucleus and cytoplasm because of similar staining densities. With Giemsa's stain the nucleus is strongly basophilic.

The lymphocyte in unstained and in vital-stained preparations is actively ameboid. During movement, the pseudopodia are elongated and thread-like.

Monocyte.—This cell is round and is the largest of the white cells. With Giemsa's stain, the basophilic nucleus and cytoplasm are uniformly pale blue. No granules are visible in any region of the cell.

Small vacuoles are commonly seen surrounding the nucleus. In some cases they coalesce to form a crescent-shaped area between the nucleus and cytoplasm. There are other, smaller vacuoles which are scattered randomly throughout the cytoplasm. The location of the vacuoles is readily seen with vital staining which colors these bodies reddish after which the remainder of the cell takes on a lesser pinkish-red. The monocyte in Figure 1 has been treated by vital staining which enlarges it in comparison with Giemsa and unstained preparations. This cell shows weak motility in some but not all unstained preparations.

Heterophil (*neutrophil*).—This cell is large and round. It so closely resembles the eosinophil that it has been disclaimed as an individual type (Charipper and Davis ,1932). The heterophil is defined herein as a distinct entity because it can be readily characterized microscopically.

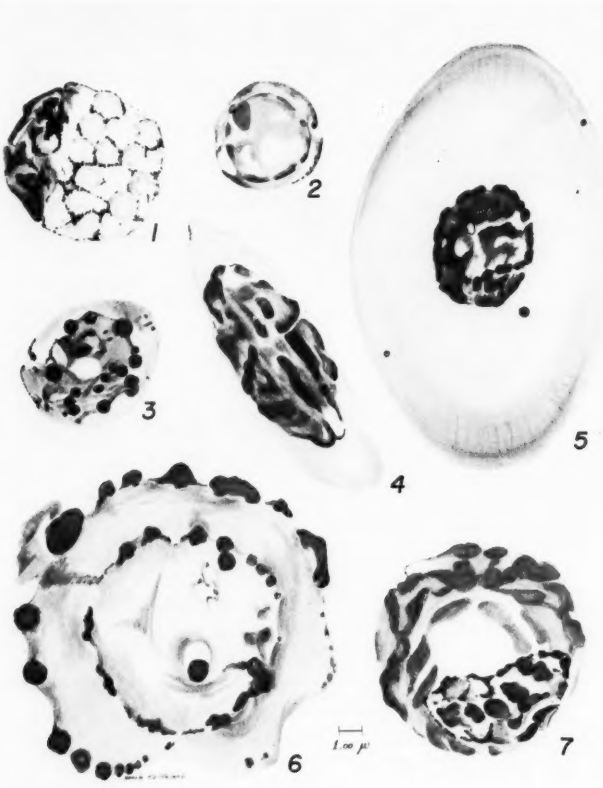

Fig. 1.—Morphology of the blood cells of *Pseudemys scripta elegans*. The cells have been drawn to scale with an ocular micrometer. 1. eosinophil 2. lymphocyte 3. basophil 4. thrombocyte 5. erythrocyte 6. monocyte (which is somewhat enlarged in the vital stain in which it was drawn). 7. heterophil.

The cytoplasm of all the cells is finely granulated, which is not apparent in these drawings.

The cytoplasm contains many rod-shaped, eosinophilic granules, as seen with Giemsa's stain. A characteristic cytoplasmic structure is an almost constant central space which can occupy about one-half the total area of the cell. This space contains few or no inclusions.

The nucleus is rather strongly basophilic and has a polar location.

The heterophil is distorted easily and its typical round shape is not always preserved. The cell is motile in unstained and vitally-stained preparations and cytoplasmic granules also show movement.

Eosinophil.—This cell is a distinct type. Unlike the heterophil, it has no central space. The cytoplasm is crowded almost to bursting with granules which are spheroidal, all of similar size, and deeply eosinophilic. All told, the eosinophil is denser and distinctly more acidophilic than is the heterophil.

The basophilic nucleus always has a distinctive polar position. This arrangement resembles a cap as it does in the heterophil, giving both cells a signet-ring appearance. There are many irregular nuclear inclusions which are strongly basophilic.

The cell is motile in unstained and vital-stained preparations. The individual cytoplasmic granules also show definite movement.

Basophil.—This cell, called a mast cell in early papers, is just larger than a lymphocyte and is typically round. In stained smears it often shows surface indentations that suggest motility. Pseudopodia are not seen.

Where the nucleus is visible, in stained preparations, the cytoplasm is found as a peripheral ring. In the stained smear the cell granules are spheroidal and strongly basophilic. They are smaller and less numerous than those seen in the unstained or vital-stained preparations. The cytoplasmic granules in vital staining obscure the nucleus and seem to pack the cell. These granules are always smaller than those of the eosinophil.

The nucleus is round and homogenous in unstained preparations.

Because of a definite and constant basophilic reaction in both nucleus and cytoplasm, and the central nuclear location, this cell is considered herein to be a distinct type.

Thrombocyte.—This cell, also called a spindle cell, is characteristically elongate. It is about three-fourths the length of a red cell and about one-half as wide.

The cytoplasm extends well beyond the limits of the central oval nucleus. The matrix is very slightly acidophilic with a density approximating that of a red cell. No cytoplasmic granules are visible.

The nucleus is strongly basophilic, staining more densely than

the basophilic nucleus of the red cell. One or more incomplete longitudinal furrows are commonly seen running through and subdividing the nucleus to segments.

The cell displays no motility in unstained or in vital-stained preparations.

Discussion

The cells are described as entities on the basis of constant, unique staining reactions and also of characteristic morphology and inclusions. There is every indication that all adult blood cells in *Pseudemys scripta elegans* have been described. Immature forms are rarely seen in the circulating blood.

Examination of unstained and vital-stained cells indicates that the property of motility resides in the lymphocyte, eosinophil, heterophil and to a smaller extent in the basophil and monocyte. Phase contrast observations might have brought out these facts more readily, but were not used.

The literature on the blood cells of turtles is confusing. This is due partly to species differences. Thus, Bernstein (1938) stated that *Testudo geometrica* has red cells which stain differently in each half of the cell.

The turtle eosinophil has been the subject of controversy partly because more than one type of cytoplasmic granule has been described in this cell (Jordan and Flippin, 1913; McCauley, 1953). Where Charipper and Davis (1932) believe that there are two types of eosinophils, one called a heterophil, the evidence herein indicates that the heterophil (neutrophil) is a distinct type. This agrees with Ryerson (1943).

Some of the discrepancies are traceable to the preparative technique. It was found here that Wright's stain in some cases enlarges the eosinophil and heterophil, and also their granular inclusions. This gives a false impression of giant cells that do not appear in unstained blood. This could explain such cells described by McCauley (1953) in *Chrysemys picta*.

Although McCauley listed eleven varieties of cells in the adult painted turtle, we have found only the same types in the circulating blood as in *Pseudemys*. There are, however, visible differences in the sizes of comparable cells.

Since cell counts vary significantly with the seasons of the year (Kaplan and Rueff, 1960). the counts in Table 1 were done in early spring only. The counts still show unduly great variability which we believe is in great measure due to lack of control over the homogeneity of the turtle colony, particularly with regard to internal parasites that produce no gross symptomatology. McCauley (1953) listed for *Chrysemys* total counts of the same order of magnitude and also with high variations.

Because, for humane reasons, the turtles were injected intra-

peritoneally with Nembutal, 20 mg./kg., we compared in a few instances the blood of anesthetized and unanesthetized specimens, but no real morphologic differences were found.

Observations of the standard deviations particularly for the eosinophil and thrombocyte (Table 1) emphasize the enormous variation in differential counts that may be expected.

Summary

All cell types present in human blood occur in the pseudemyd turtle, *Pseudemys scripta elegans*. Information has been presented concerning the cell and nuclear size, and also their morphology, their total and differential counts. The distinctness of the cell types has been emphasized. The use of unstained preparations is necessary to differentiate cell artifacts.

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The Parathyroid Glands of *Bufo viridis* Laurenti

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I. Introduction

Controversial findings concerning the effect of parathyroidectomy in various anurans led to this study. In *Rana catesbiana*, the total extirpation of the gland is followed by tetanic spasms and death within 4 days, unless replacement therapy is applied (Waggener, 1930; Fleischmann 1951:78). But, according to Pickford and Atz (1957:175), parathyroids of newts and frogs are not essential for life, although there have been claims to the contrary.

Rana pipiens survived the complete extirpation of the glands without any sign of tetany (Cotelyou 1958:424).

In this paper, first, the development and histological differentiation of the parathyroids of *Bufo viridis Laur.* is described, and then the effect of parathyroidectomy is dealt with and its possible explanations discussed.

II. Materials and Methods

The parathyroid glands of 41 tadpoles and adults, up to an overall length of 5 cm., were investigated. Tissues were fixed in 6-10% formalin or Zenker-formol. Complete series of transverse sections of the larynx region, including the gills in young specimens, were prepared. Sections were generally 10μ thick; occasionally, only 8μ. Ehrlich's hematoxylin and eosin were adopted as standard stains; Heidenhain's Azan was used to expose the connective tissue of the gland.

Forty-six animals were parathyroidectomized. The toads were anesthetized with ether and laid on their back. An incision was made, exposing the sinus sternalis of either side, and with sharpened forceps, the glands were extirpated. Then, the flaps of skin were pulled over the wound, whose healing proceeded without any complication. The animals were operated on between August 20 and November 26. The activity of the glands may undergo seasonal changes, so the date of the operation may influence the results.

Unoperated and sham-operated specimens were used as controls. After intervals ranging from 12 to 246 days, the animals were sacrificed. Again, serial sections of the whole region were prepared, as described above. The sections were examined to determine the degree of success of the operation and in addition, to see if any ectopic or regenerated parathyroidal tissue was present.

The influence of parathyroidectomy on other organs, especially on other endocrines, will be described in another paper.

III. Analysis of Development and Histological Differentiation of the Parathyroids

In *Bufo viridis*, the parathyroids originate, as is typical of amphibians (Maurer, 1888), from the ventral part of the third and fourth pharyngeal pouches of both sides. Here, four small solid balls of crowded epithelial cells develop. The ovoid cells have conspicuous nuclei and little cytoplasm. Intercellular spaces have not been observed. Soon, capillaries abut against the borders of the organs, and a capsule develops around each of them. Later on, occasionally, an additional common capsule of tough connective tissue surrounds two organs lying in juxtaposition.

After metamorphosis, two ovoid glands are situated on either side of the larynx, close to the *vena jugularis externa* and to the *nervus hypoglossus*. Their parenchyma consists of round and whorled epithelial cells, which are either of the same type, sectioned in different directions, or of two different types. The last assumption seems likely, because after staining with Mallory's hematoxylin, two shades of blue enhance the slight contrast. Furthermore, mostly, round cells are to be found in adults. In case further examination should confirm the presence of two different kinds of cells, the question of homology to the chief and oxyphil cells of the human parathyroid will arise.

The parathyroids grow steadily, reaching their maximum size of about 200-250μ diameter two years after metamorphosis. Afterwards, a slight but significant involution takes place. In rats, a similar phenomenon is remarked upon by Willier (1955:612): at birth, the glands are twice in proportion to body weight, compared with adults. In humans, the secretion of the parathormone is known to be abundant before puberty, decreasing thereafter. In old age it is considerably reduced (Verzár, 1948:125).

It is easy to identify the glands in situ because of a typical design on their surface due to the course of blood vessels. The dense network of blood vessels bulges into the parenchyma, thus enlarging the area of contact with the secreting cells of the periphery of the gland. But neither capillaries nor erythrocytes are ever seen between the epithelial cells (Fig. 1, 2, 3) (Bargmann, 1939). Yet fine intercellular slits, comparable to the acellular bile ducts of mamalian liver, are discernible, the most minute ones being in the center, larger ones, mostly near the periphery (Fig. 2, 3). In one instance a junction of such an intercellular duct with a capillary of the envelope was recognized. In tadpoles, these slits seem to be missing.

In the human parathyroid, analogous intercellular spaces have been found, in addition to numerous blood capillaries. In the adrenals of rats and mice, too, such slits were described (Ito, 1957:325). However, the lack of internal blood supply is not common to the parathyroid of all amphibians. Capillaries are present in *Rana ridibunda* (Krause, 1923:598).

IV. The Effect of Parathyroidectomy

The toads recovered quickly from the shock of the operation. They returned to their normal position after a few minutes, and soon moved and lept as usual. They caught flies after two or three days, when the wound was superficially closed. Later, little or no scar tissue was recognizable.

After a variable period of apparent normality, an increased irritability and restlessness became manifest as the first result of the

extirpation. Next, without any detectable reason, the toad frequently rolled on its back, remaining in this position for several minutes (catalepsy). A certain weakness and loss of appetite, occasionally accompanied by carpopedal spasm and fibrillations, indicated the outbreak of the tetany. The first seizures started, if the animal was touched or caught. Later, in addition, spontaneous, violent convulsions took place: the toad, lying on its belly, occasionally on its back, was shaking and quivering. Fibrillary twitching was noticed in the toes and fingers. The eyes and lungs were bulging (Fig. 4, 5). The floor of the mouth moved up and down, rapidly, compensating for the lack of lung respiration, due to the latter's paralysis. The severity of such fits was variable and their duration ranged from a few seconds to several hours. The longest observed lasted for more than 9 hours.

In the intervals between seizures, ranging from hours to days or even weeks, the animals behaved normally. Sometimes, a certain hyperexcitability was exhibited. Animals, suffering from repeated attacks, would often lie on their bellies for hours, thus keeping a large area of their bodies immersed in water.

The time of onset of the tetany differed according to the date of the operation. Animals which were operated between August 29 and November 2 suffered from the first seizure as soon as 2 to 8 days after the operation. The later the excision, the greater the time of latency. Animals operated in November, passed through a period of apparent normalcy from 20-40 days.

Yet, in two toads which were operated on November 17, the first attack was observed no sooner than after 138 days. In these cases, it must be taken into account that the animals were not watched around-the-clock, which fact might be responsible for these and other exceptions.

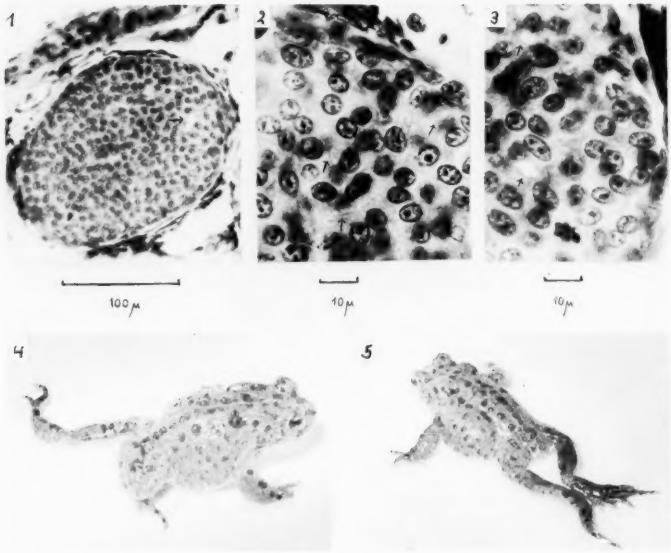
The animals which were parathyroidectomised at the end of November exhibited subtetanic symptoms in the third week and the first typical seizure 26-30 days after the extirpation.

Special attention must be paid to the two largest toads, one of an overall length of 4 cm., the other of almost 5 cm. When the glands were excised, their extraordinary smallness was noticed; the volume of the organ was one third less, compared with the others. No subtetanic symptom whatsoever, indicating a seizure, was detectable for a long time. The toads behaved entirely normally. But after 98 days, a fit with typical convulsions and twitching set in. More seizures followed after relatively long intervals, during which the animals recovered completely.

Some specimens suffered from an edematous condition: the tongue and the floor of the mouth were swollen. Occasionally the normal condition was restored. When the toad was sacrificed, the urinary bladder was found to be expanded, containing a greenish

fluid. These symptoms are not exclusively characteristic of parathyroidectomised animals, since the controls, too, may suffer from water retention, but never so soon and never so severely. It may be assumed that water retention may be intensified post-operatively.

In cases where parathyroidectomy was only partially successful, either no abnormality at all or some hyperexcitability were observed. The degree of severity may depend on the quantity of undamaged parathyroidal tissue, left in the organism and on the quantity of parathormone, circulating in the blood. This may be further decreased, due to bleeding during the operation.



EXPLANATION OF FIGURES

All sections were stained with Hematoxylin (Ehrlich) and Eosin.

1. Adult: total length 3, 5 cm. The parathyroid consists of epithelial cells surrounded by a dense capsule with blood vessels, and chromatophores. The arrow points to two intercellular ducts joining each other.

2. and 3. The same specimen, but another slide. No capillaries in the glandular parenchyma. Again, all the arrows point to acellular, intercellular ducts of different diameter, cut longitudinally and/or transversly.

4. Toad during seizure of tetany. The eyes and lungs are bulging. The position of the limbs and toes is typical. The shadow, cast by the left hind toes, results from fibrillations during the attack.

5. Another typical position. No fibrillations.

Nothing definite can be said about the regeneration of the gland. The number of mitoses is increased in a remnant, thus explaining the complete recovery of animals, in which the operation was only partially successful.

Discussion

The parathyroid of *Bufo viridis* differs histologically from the well-known glandular structure of other anurans, e.g. *Rana* and of mammals, in lacking an internal blood supply. Further investigations are indicated to determine whether such an avascular endocrine might be revealed in other amphibians. The lack of capillaries cannot be explained by the smallness of the glands, because in other genera, parathyroids of similar size are rich in blood supply. Besides, the ultimobranchial body of *Bufo* is densely vascularized; though rarely greater than 200-250μ. It may be assumed that the secretion of the hormone into the intercellular slits is a primitive feature, which is partly retained, in the mammalian parathyroid and adrenal, in addition to the capillary-network.

Another point of interest is the effect on *Bufo* and on other anurans of parathyroidectomy compared with mammals. With the exception of rats, the extirpation proves to be fatal in mammals, contrary to most amphibians, in which the gland is not essential for life. Of course, their well-being is impaired after the operation.

A possible explanation seems not to be found in a different function and quality of the gland itself, but in the different mode of respiration in either group. In mammals, the post-operative calcium deficiency causes spasticity and, finally, paralysis of the respiratory muscles. Unless replacement therapy is applied, death ensues by asphyxiation, which proves to be a secondary, though drastic, effect. The severity of the tetany may vary with the species, with the content of calcium in the diet, with the season and with the age of the organism (Verzár, 1948:126). Experiments with dogs and cows confirm this suggestion (Stott and Smith, 1957:900). In *Bufo* respiration through the skin and the floor of the mouth replaces the malfunctioning lungs until the attack is over.

The penetration of calcium through the skin may explain the diminishing frequency of seizures. The favorite position of the animals when deprived of their parathyroids, lying on their belly, may be understood as compensatory: the area of contact with the water is enlarged and, accordingly, the quantity of oxygen and calcium ions transferred into the organism may be increased.

The delayed onset of the first seizure after parathyroidectomy during November, compared with that in earlier months, reflects a seasonal change of the gland's activity; the relatively long period of latency [till the outbreak of the tetany] in the largest animals may indicate decreased activity of the gland in older age. This

agrees well with the reduced size of the parathyroid of adults. A degeneration of the gland during October, November, December was also observed by Cortelyou et al (1960:445) in *Rana pipiens*. Decreased activity due to the combined factors of season and age may enhance the effect of delayed manifestation of attacks.

The histological and physiological changes of the parathyroid during a whole year in animals of different ages must be investigated. Perhaps, it will be possible to explain the absence of tetany after parathyroidectomy in some amphibians as a consequence of the reduced activity of the gland at the time of the operation.

Summary

1. The development and histological structure of the four parathyroids of *Bufo viridis* Laur. are described.

2. The glands consist of avascular epithelium. Blood vessels are confined to the capsule. Between the glandular cells, minute intercellular channels similar to the acellular bile ducts of the mammalian liver, are evident.

3. In animals of 4-5 cm. overall length a slight involution of the glands takes place.

4. Total parathyroidectomy is followed by tetany.

5. The outbreak of the first seizure is influenced by the date of the extirpation and by the age of the toad. The larger the animal, the later the effect becomes manifest.

6. These results are assumed to reflect seasonal changes of the gland activity, and its involution in older animals.

7. The parathyroids of *Bufo* are not essential for life.

8. It is assumed that resorption of oxygen and calcium through the skin compensates for the impaired respiration, when respiratory muscles are paralyzed due to calcium deficiency.

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The Hebrew University of Jerusalem

The Distribution of Three Species of House Gecko in Bandung (Java)

GILBERT CHURCH AND LIM CHUN-SIM

The city of Bandung is situated on a mountain plateau in West Java about 2400 feet above sea level. It enjoys a mild climate, the temperature averaging three or four degrees cooler than the coast, but the relative humidity and the amount of rainfall are about the same as at sea level. In spite of seasonal differences in the amount of rain, there always is an abundance of insects to satisfy the appetites of the "tjitjaks," as the house geckos are commonly called, and they thrive at all times of the year.

The early city was built around a square. As it has grown, the residential districts have moved farther and farther out from the old center, which now is situated in the commercial district. The square and the area enclosed within a radius of one kilometer around it are occupied by warehouse buildings, shops, meeting halls, theaters, garages and small factories. There is a typical dearth of vegetation, much noise and traffic, hordes of people day and night, and in the evenings many electric lights are burning.

As one moves away from the commercial district, substantial residential houses become predominant. They are usually surrounded by gardens and trees; there is increased dampness, and although many houses burn night lights, there is a decided decrease in the amount of illumination. By the time one is three kilometers away from the square the atmosphere has become distinctly suburban. There are occasional rice paddies; large houses are scarce but the smaller new houses and the poorly illuminated, crowded, thatched bamboo houses are more numerous.

In this gradually changing environment from the busy center of town to the rural outskirts, the three species of small house gecko inhabiting Bandung are found in varying ratios to one another. Observations made on approximately 1500 specimens

collected at regular intervals throughout 1960 suggest that the variations are determined by different adaptive behavior patterns.

For the most part the three species were captured outside buildings at night, when two of them at least tend to gather around the lights to catch insects. They were brushed off the walls or ceilings with a mop made of bamboo and a rag, and picked up before they could run off. Like cats, they always landed feet first. All of them were able to drop their tails, sometimes simply by shaking themselves vigorously, and numerous specimens with regenerated tails were found.

Cosymbotus platyurus.—Of the three species, *Cosymbotus platyurus* is the most alert and active and ventures farthest from a possible hiding place. It runs faster, is most difficult to catch, and when caught is quick to find a means of escape if one exists. It seems to have an acute sense of sight but is undisturbed by loud sounds. Unlike *Hemidactylus frenatus,* it rarely if ever bites. It chooses to inhabit brightly illuminated places and is the most gregarious of the three species, being usually found in groups of five to twenty. As might be expected, it is found in greater numbers in the noisy and bright commercial center of Bandung where its aggressiveness and speed make possible its survival in such an environment. Eighty per cent of the animals caught within a radius of one-half kilometer of the square were *C. platyurus,* but this percentage declined steadily in collections made further from the square. See Table. 1.

TABLE 1.—Numbers and percentages of three species of house gecko collected in different areas in Bandung (Java). The town square was used as a central point from which the circles were drawn.

Area	*C. platyurus*		*H. frenatus*		*P. mutilatus*	
	No.	%	No.	%	No.	%
Radius of ½ km. from square	100	80.0	12	9.6	13	10.4
½ to 1 km.	156	52.5	104	35.0	37	12.5
1 to 1½ km.	126	36.2	162	46.5	60	17.3
1½ to 2 km.	73	31.0	145	61.7	17	7.3
2 to 2½ km.	61	22.4	169	62.1	42	15.5
2½ to 3 km.	46	21.0	144	65.7	29	13.3
Totals	562		736		198	

Hemidactylus frenatus.—This species is the most abundant of the three species. It also prefers bright places and is sometimes found in small groups or together with *C. platyurus* gathered around a light in its search for food. Unlike *C. platyurus,* it is not found in dry places but chooses rather to live in the damper but well-lighted residential areas of town. Occasionally *frenatus* is found on wayside trees and will frequently bite when caught. Only 9.6 per cent of the animals captured within a radius of one-half kilo-

meter of the square were *H. frenatus,* but the numbers increased rapidly as one moved toward the outskirts of town (Table 1).

Peropus mutilatus.—This is a solitary gecko in Bandung and is almost always found alone rather than in groups. Its skin is much more delicate than that of the other two species and is easily damaged. Perhaps because of this it is shy and much less aggressive. Unlike *C. platyurus* and *H. frenatus,* which congregate around lamps, it is rarely found in bright surroundings and seems better adapted to dark places. It tends to be inactive and when disturbed is most likely to lie flat against the wall rather than to seek a hiding place as do the other two species. It never bites when caught but often urinates on the captor. This species was occasionally found with *H. frenatus* but seldom with *C. platyurus.* It occurred with equal but minor regularity from one end of town to the other (Table 1) and was collected in largest numbers in empty classrooms and dark, damp bathrooms. The Institute of Technology in Bandung is dominated entirely by this species and *H. frenatus;* and one of us (Church) shares the inside of his home on the outskirts of town with *P. mutilatus* and the outside with *H. frenatus.*

Conclusions.—Light and moisture are apparently the important environmental factors limiting the habitats of these three gekkonids in Bandung; and the limitations are set by the extent of the aggressiveness of each species. Although all three are found throughout the city, it is significant that the figures and percentages given in Table 1 show that the energetic and alert *C. platyurus* prefers and dominates the well-illuminated, dry commercial district, and the almost equally aggressive *H. frenatus,* the damper and darker residential areas. The solitary and shy *P. mutilatus,* however, is found in the darkest, most secluded places.

Consideration of the three different habitats indicates that food preference may also play a role in the distribution of the three species. *P. mutilatus,* as illustrated, rarely ventures into bright light and must exist on a different diet than the other two. Studies of the stomach contents of the three species would be perhaps revealing.

Observations have shown that individuals appear to exert territorial rights over their own particular areas, and the dominant aggressiveness of a species, which has nothing to do with size in this case since the average snout-vent lengths and weights are all comparable, is probably also important in determining a species locale. In the laboratory *C. platyurus* and *H. frenatus* males kept in cages fight with any new individual added to the colony until he retreats into a hiding place. The bite of *H. frenatus* does not injure other *H. frenatus* or *C. platyurus* individuals, but it conceivably could be harmful to the thin-skinned *P. mutilatus.*

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Notes

OBSERVATIONS ON THE DEVELOPMENT OF *DESMOGNATHUS* EGGS UNDER RELATIVELY DRY CONDITIONS.—This note derives from a study made on the development of eggs of *Desmognathus fuscus fuscus* in conditions other than the expected moist habitat. The observations were made in the vicinity of Ford's Creek near the town of Wesson, Lincoln County, Mississippi in the fall of 1956.

Females with eggs were found in a small depression beneath a partially buried log where there was no standing or running water within 500 yards of the nesting area. The depression had a maximum depth of 5½ inches and a maximum length of 3 feet 7 inches and provided very little moisture.

During incubation the eggs increased in size to a greater degree than those observed under the usual conditions for the same length of time.

While the females were not always with the eggs during the night, at no time during the day were they absent from the nest. They were not always coiled about the eggs when attending them at night; however, it was a common practice for them to crawl about the eggs. In doing so the females would moisten the eggs by expelling water on them. During the day they would coil around the eggs, crowding them closer together. In the laboratory, when the female and her eggs are placed above water, she will go to the water, but has never been observed taking the eggs to the water. Several times at night I have observed salamanders coming out from under logs and crawling around in the grass where dew has fallen, and I assume they get water in that manner.

As the eggs developed the larvae remained within a sheath filled with fluid. With the aid of a hand lens an air space was observed in the top of the sheath. The young larvae would spin about within the sheath at a rapid rate and at regular intervals, possibly suggesting an oxygenating process of the fluid as oxygen entered the semipermeable membrane. Following this action the fluid was filled with thousands of minute air bubbles.

Some of the sheathed larvae were put in a container and placed in a shallow stream. After four hours the sheath swelled and broke and the larvae swam free within the container. Some of the larvae were freed by pricking the egg with a pin. No ill effects were noticed. The larvae of this study remained within the sheath much longer and were larger when freed than those developed in the usual habitat. A heavy rain prevented further observations on this study, as remaining larvae were freed with the flooding of the depression.

I have observed females with eggs many times and for long

periods of time and have never known *Desmognathus* to move its eggs (singly or attached) into a "hole" or other place during a dry spell, as reported for south Texas specimens by Strecker (Proc. Biol. Soc. Washington, 21: 47-52, 1908). It would be quite an undertaking for the females to move some of the large clutches that I have observed, under any condition.—W. E. Brode, *Gulf Coast Research Laboratory, Ocean Springs, Mississippi.*

THE SALAMANDER *SIREN INTERMEDIA INTERMEDIA* LECONTE IN NORTH CAROLINA.—The northernmost limits of *Siren intermedia intermedia* along the Atlantic Coastal Plain are presently undetermined. General sources such as Bishop (1947:459), *Handbook of Salamanders;* and Conant (1958:388), *A Field Guide to Reptiles and Amphibians of Eastern North America,* show it ranging into South Carolina south of the Pee Dee River. Some authors (Bishop *loc. cit.;* Goin, 1942:217, Annals Carnegie Mus. 29) also refer to a dubious record (Noble and Marshall, 1932, Am. Mus. Nov., 432:7) of an individual from Guiney Station, Virginia, but specimens have previously been lacking from the area between South Carolina and Virginia. The localities recorded below definitely extend the range of *Siren i. intermedia* into North Carolina in the Cape Fear, Neuse, Pee Dee, and Waccamaw river systems.

North Carolina specimens (Table 1) are from *Bladen Co.,* 4.7 mi. S Dublin, April 4, 1958 (Cornell University 6408); *Columbus Co.,* 1 mi. N Waccamaw River near Ash, March 29, 1949 (CU 5483); *Craven Co.,* 2 mi. SE Havelock, March 26, 1958 (U. S. National Museum 142718-9); *Hoke Co.,* 1.6 mi. W Rockfish, January 6, 1959 (Univ. of Michigan, Museum of Zoology 118903). They do not differ appreciably from nominate *intermedia* as described by Goin (1957, Herpetologica 13:39-42).

While there are comprehensive accounts of the food of *Siren i. nettingi,* nothing other than a note by Carr (1940, Univ. Florida Publ. Biol. Ser. 3(1):51) has been published on the food of the nominate subspecies.

In the stomach of CU 6408 are eight *Siren* eggs (3.0-3.5 mm), a small pebble, and some aquatic vegetation wrapped around the eggs. CU 5483 contains insect and crustacean remains, including a dragonfly naiad and isopods. Each of two individuals, USNM 142718-9, had a single *Siren* egg and plant material. Both specimens, UMMZ 118903, have stomachs filled with filamenteous algae and detritus. Fortuitous ingestion of plant material along with normal invertebrate food and *Siren* eggs was suggested by Scroggin and Davis (1956, Herpetologica 12:231-37) and is indicated here.

TABLE 1.—Variation in *Siren i. intermedia* from North Carolina. Measurements are in millimeters.

Character	CU 6408	CU 5483	USNM 142718-9		UMMZ 118903	
Total Length	190	150	137	125	252	141
Tail Length	62	51	46	39	89	43
Total L. / Tail L.	3.06	2.94	2.98	3.21	2.83	3.28
Head Length	16	13	12	12	17	12
Costal Grooves	32-32	33-33	32-33	31-31	34-34	33-33
Finger Reduction	4,1,3,2	4,3,1,2	4,3,1,2	4,1,3,2	4,1,3,2	4,1,3,2

Bishop (1947:461) stated that nothing was known about the breeding habits or eggs of *Siren i. intermedia*. Spawning in North Carolina must take place in late March and early April, for *Siren* eggs were found in the stomachs of CU 6409 and USNM 142718-9, as reported above. The water temperature at the former collection was 54°F. There were 70 large (2.5-2.9 mm.), 10 medium (2.0-2.1) and 55 small (1.4-1.5) eggs in the right ovary of CU 6408; the left ovary contained 60 large, 6 medium and 38 small eggs. UMMZ 118903 had 125 and 144 large eggs in the right and left ovaries respectively. One-half to one-third of the surface of the large eggs is entirely pigmented as in *Siren i. nettingi* (Davis and Knapp, 1953, Copeia (2):119-121). Ovaries of these specimens ranged from 40-53 mm. in length. CU 5483 and UMMZ 118903 are probably immature, because their ovaries are only about 15 mm. long and are filled with small undeveloped eggs.—BRUCE B. COLLETTE AND FREDERICK R. GEHLBACH, *Rm. 71, U. S. National Museum, Washington, D. C., and Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

MATING BEHAVIOR OF THE PANAMINT LIZARD, *GERRHONOTUS PANAMINTINUS* STEBBINS.—The mating behavior of two species of alligator lizards, *Gerrhonotus coeruleus* and *G. multicarinatus* has been described by Fitch (1935, Trans. Acad. Sci. St. Louis, 35:3-38, 4 pls.), Vestal (1940, Copeia, p. 51), and Svihla (1942, Copeia, p. 54). These were based on field observations. We are now able to add some notes on this behavior in the very rare Panamint alligator lizard, *G. panamintinus* Stebbins.

Three specimens of *G. panamintinus* were obtained in Grapevine Canyon, Nelson Mts., Inyo Co., California, two males in June, and one female in September, 1960. The three have been kept alive in a glass terrarium at a fairly constant room temperature of 20°C. at the California Academy of Sciences. They have been fed a diet of meal worms and have been provided water. Otherwise the animals have not been disturbed.

On May 15, 1961, at 3:10 p.m. the smaller of the two males (92 mm. snout-vent length) was found copulating with the larger female (110 mm. snout-vent length). The large male (122 mm. snout-vent length) seemed totally disinterested in the proceedings and was removed from the glass container shortly thereafter. The position assumed by the mating pair (fig. 1) closely parallels that diagrammed by Vestal (*loc. cit.*) for *G. coeruleus*.. At 4:16 p.m., though cloacal contact ceased, the male continued to grip tenaciously the female on the left side of the temporal region. The pair moved about in a circle, the female initiating all movements, the male retaining his hold throughout. These movements, though not vigorous, seemed directed to forcing the male to release his grasp, which he did not do. The female occasionally extended her tongue and vibrated her tail slightly; also, several times she appeared to try to push the male's head away with her left foreleg, without success. Throughout these activities the male tried to keep his left hindleg around the posterior dorsum of the female; when dislodged from this position he would make immediate efforts to resume it.

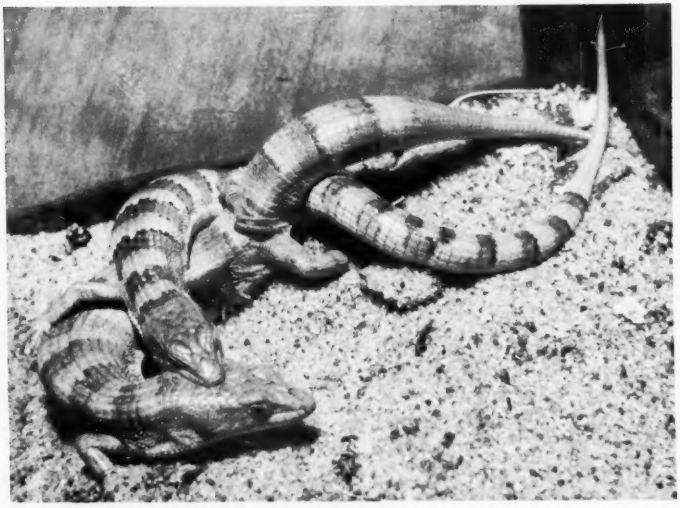

Fig. 1.—*Gerrhonotus panamintinus* mating, May 15, 1961.

On the following morning (May 16) the male was found (9:00 a.m.) still grasping the female's head with his jaws, and at 9:45 a.m. the pair was observed again in copulation. No further changes

were observed during the rest of the day. The next morning (May 17) the two animals were found copulating when we arrived at the laboratoy at 8:55 a.m. However, by 9:30 a.m. they ceased copulating, and for the first time the male relaxed his grip on the female, and the two separated completely. No further attempt was made by the male to secure the female nor did the female show any signs of aggressiveness.

In an earlier report Fitch (*loc. cit.*) remarked on the apparent indifference to their surroundings of a mating pair of *G. multicarinatus* he had observed. A similar behavior, or lack of response, was noted in our *G. panamintinus*. Neither of the pair seemed to be disturbed by outside movements, even when these involved alterations of the interior of their tank. In preparing to take photographs of the animals it was necessary not only to move the tank to a more favorable position, but also to remove the cover, to remove two large twigs and the water dish from inside the tank, and to smooth the sand immediately surrounding the pair. At no time did either individual show any response to these activities.—Benjamin H. Banta and Alan E. Leviton, *California Academy of Sciences, San Francisco 18, California.*

ANKYLOSIS AND XANTHISM IN THE EASTERN WORM SNAKE.—On May 25, 1950, an adult female eastern worm snake (*Carphophis amoenus amoenus* Say) was captured near Severna Park, Anne Arundel County, Maryland. The specimen was found coiled in a small depression beneath a pine log. Examination indicated the snake was carrying three eggs vaguely discernable through the lower abdominal wall.

She was subsequently placed in a terrarium containing five inches of sawdust and laid three eggs on June 2, 1950. Although the eggs were laid in a random manner, all were deposited at a depth of two inches in the sawdust. The eggs were removed from the original terrarium and placed in a smaller one more convenient for insuring proper development. They were checked routinely and appeared normal in every respect. As time progressed, the eggs slowly enlarged, typifying normal development.

During the last week of July, the eggs were left unattended. When next observed, it was noted they had dehydrated considerably, and all three were extensively collapsed and shrunken. Although the damage appeared beyond repair, they were sprinkled with water and replaced in a damp terrarium. Two days imbibition was sufficient to effect a normal contour.

On August 1, 1950, the first egg hatched and the remaining two the following day. The first specimen to hatch was physically unimpaired but exhibited a striking aberrant color pattern. Normal

coloration would be a reddish-brown dorsum with pink venter. This specimen, 86 mm. in length, was a light brownish-yellow with a light cream colored venter. The eyes were also light yellow in color. The snake was an example of partial if not complete xanthism.

The two remaining hatchlings had normal coloration but were physically impaired. They both measured 85 mm. in length and exhibited marked ankylosis of the spine in four places. The points of ankylosis were located in the same areas in both specimens but one snake was much more crippled than the other. One was adjacent to the vent, while two others were clearly defined by the sharp angles formed by the anterior third of the body. The remaining point of ankylosis, which was not as severe as the other three, was located in the cervo-cranial region. Locomotion was possible but an attempt to move in any direction resulted in lateral movement or movement at right angles to the desired path of locomotion.

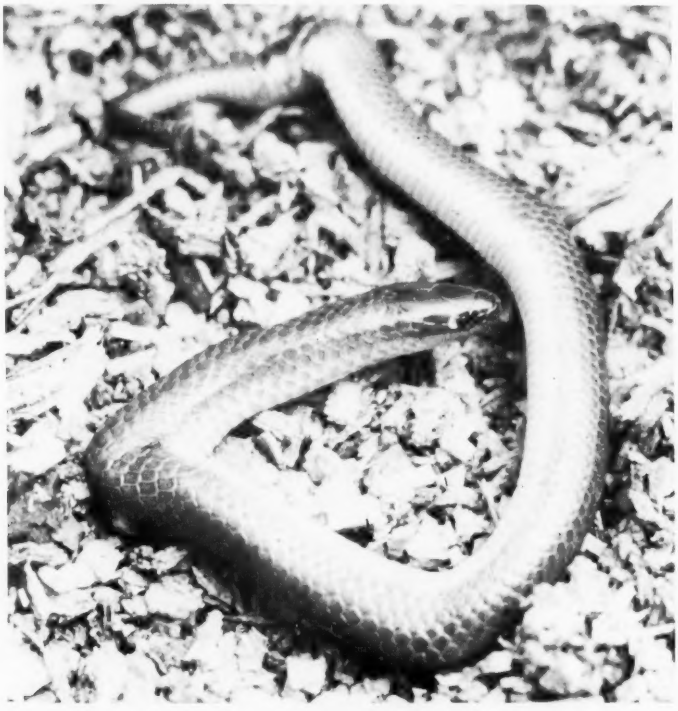

Fig. 1—A recently hatched eastern worm snake (*Carphophis amoenus amoenus*) with ankylosis of the spine in four places.

In both individuals exhibiting ankylosis, the points of consolidation corresponded to the acute angles the embryo made within the ends of the developing egg. It seems probable that the crippling ankylosis was a direct result of the dehydration suffered by the developing eggs. However, the dehydration was probably not a factor in producing the xanthism since pigmentation is usually considered to be determined by prearranged genetic pattern. Since all three eggs underwent the same degree of dehydration, it is notable that the only individual to escape was the xanthic specimen. This may be a matter of coincidence; however, further investigation is desirable. The specimens are in the senior author's preserved collection.—ROBERT S. SIMMONS AND CHARLES J. STINE, *Department of Herpetology, Natural History Society of Maryland, Baltimore, Maryland.*

A RECORD OF THE RED-BELLIED SNAKE FROM TEXAS.—The Red-bellied Snake, *Storeria occipitomaculata* (Storer) has been one of the most elusive snakes in Texas herpetology. Brown, (1950, An Annotated Check List of the Reptiles and Amphibians of Texas:196) states that "A single record of this subspecies is available for Texas but there is no definite locality cited".

Robert MacEwan and Clay Touchstone, both formerly of Beaumont, (personal communication) collected two specimens from opposite sides of Pine Island Bayou on State Route 105 between Beaumont and Sour Lake in December 1948. Since the bayou is a county line, one was in Jefferson county and the other in Hardin county. Both were under decaying logs. The same two collectors found a third west of Vidor in Orange county, under a decaying log. All three were supposedly sent to the University of Texas but the specimens were lost.

The field biology class from Lamar State College of Technology, working the Hebert woods in the southwest limit of Beaumont, Jefferson county, March 3, 1961, found a specimen which is now preserved in the Lamar Collection as OP 306/7. Mel Bradburn and Don Henderson rolled a log on a small hummock surrounded by water and came up with the specimen, which was active, attempting to regain the cover of the log when disturbed.

Hebert's woods consists of second-growth hardwood with a summer canopy so dense that very little ground cover is present. Greatest elevation in the woods is only 10 feet above sea level and much of the area is subject to irregular flooding, particularly during the winter and spring. On the other hand, dry spells during the summer cause the same soil to dry out and show deep cracks. Hillebrandt's Bayou borders the woods and presents a spoil bank

some 25 feet high. The snake was collected 20 feet within the woods from the base of the spoil bank.

Data recorded from the specimen are as follows: female, seven developing eggs in each ovary; length 216 mm.; tail 50 mm., tail 23.1 per cent of total length; scale rows 15-15-15; ventrals 130; caudals, 51; preoculars, 2-2; postoculars, 2-2; upper labials, 6-6; lower labials, 7-7. Three spots at the base of the head rust colored and distinctly separated.

The back is considerably darker than that of a Texas Brown Snake, *Storeria dekayi texana* Trapido, collected under debris on the dry spoil bank the same day. Black coloring on the sides of the body reaches into the lateral edges of the ventral scutes and a single irregular row of small dark spots is more medial on each side.

From Conant's (1958: A Field Guide to Reptiles and Amphibians) description of subspeciation, this snake agrees with the Northern Red-bellied Snake, *S. o. occipitomaculata* (Storer) in having the three neck spots distinct and the head moderately marked with black. It disagrees in having a light mark on adjoining ends of the fourth and fifth upper labials with no black border below instead of on the fifth only with a black border. It disagrees with the Florida Red-bellied Snake, *S. o. obscura*, which has a black head, fused neck spots and a light spot on the fifth upper labial only, but agrees with it in not having a lower black border on the upper labial spotting.—Russell J. Long, *Department of Biological Sciences, Lamar State College of Technology, Beaumont, Texas.*

FURTHER NOTES ON NON-INDIGENOUS TURTLES IN MARYLAND.—The establishment of *Pseudemys scripta* (*elegans*, *troosti* and possibly *scripta*) in Maryland, principally in the Baltimore area, has previously been noted (Cooper, J. E., 1959, Herpetologica, 15:44). Adults and young of this turtle, members of an established population of *elegans*, have recently been found at Wagner's Pond near Glen Burnie, Anne Arundel County. Specimens have been taken and observed by Mark Odell of the Baltimore City College Herpetology Club.

Two foreign chelonians, an Oriental species, *Geoclemmys* (cf.) *reevesi*, and *Graptemys kohni*, a native of the lower Mississippi Valley were also found at Wagner's Pond. In both cases the specimens taken were juveniles. Investigation discloses that pet stores in this general area handle these turtles. Mrs. Norma Rothman of the Philadelphia Herpetological Society also confirms their sale in Philadelphia.

Dr. Robert S. Simmons has advised me that many types of reptiles, including non-indigenous turtles, among them *scripta*, are

kept in a live collection display at Great Falls nature lodge near the Potomac River in Montgomery County. A guide informed me that at summer's end, all live specimens are released in the vicinity of the lodge. The possibility that *P. s. scripta*, as reported by Reed (1956, Contr. Herp. Md. and Delmarva No. 7, mimeo.) from Little Falls on the Potomac or *Trionyx ferox spinifera*, from a branch of West River (Mansueti, 1960, Chesapeake Sci.:71-72) is feral in Maryland is indicated by the finding of single adults. Thus, it is not unlikely that many non-native turtles maintain at least temporary residence in the Potomac River and its tributaries, either by escaping or by release. Dukehart (1884, Bull. U. S. Fish. Comm., 4:143) discussed an attempt to establish *Trionyx f. spinifera* in the Potomac River near Cumberland in 1883. This attempt apparently failed.

The practice of releasing non-native forms into any area is, at best, a poor idea. As constantly pointed out by herpetologists, the acquisition of accurate distributional data is difficult enough without having the picture inadvertently or deliberately clouded in this fashion.—JOHN E. COOPER, *Department of Herpetology, Natural History Society of Maryland, and Baltimore City College, Baltimore, Maryland.*

AN EXCEPTIONALLY LARGE ALLIGATOR LIZARD.—A large male alligator lizard, *Gerrhonotus multicarinatus webbii*, number 61 in the Los Angeles City College collections, exceeds the maximum recorded length for this species. The specimen was collected by Mr. J. C. Von Bloeker in April 1932 near Agua Caliente, three miles east of Tijuana, Baja California, Mexico.

Van Denburgh (1922, Occ. Pap. Calif. Acad. Sci., 10:457)

Fig. 1.—Lateral view of *Gerrhonotus multicarinatus webbii* (No. 61, L.A.C.C.). Scale in inches.

lists a specimen of *Gerrhonotus multicarinatus webbii* with a snout-vent length of 164 mm. and a head width of 30 mm. Fitch (1938, Amer. Midl. Nat., 20:397) records a specimen measuring 170 mm. in snout-vent length. The L.A.C.C. lizard exceeds this latter record by 5 mm.

Measurements of the L.A.C.C. specimen are in millimeters and follow Stebbins, 1958 (Amer Mus. Novit., No. 1883:2): Snout to vent, 175; tail, 164 (of which 106 is regenerated); head width, 35; head length (to anterior margin of ear opening), 36.5; greatest depth of head, 32; axilla to groin, 94; anterior border of insertion of forelimbs to tip of snout, 58; forelimb (from point of limb insertion to outer curve of nail of longest toe), 42; hindlimb, 50; greatest width of tail, 17.5. Scutellation: dorsal scale rows; right 41, left 40; ventral scale rows (mental to preanal inclusive), 62; longitudinal dorsal rows, 14; longitudinal ventral rows, 12.

The photograph is by courtesy of Mr. Harford Bridges.—Edward D. Mitchell, Jr., *Department of Zoology, University of California, Los Angeles.*

THE RIBBON SNAKES OF SOUTHERN MISSISSIPPI.—Wright and Wright (1957, Handbook of snakes: 767, map) indicate that *Thamnophis sauritus* Linnaeus does not occur in southern Mississippi; its range is given in part (*op. cit.*:824) as "east of the Mississippi River to central Mississippi." This does not agree with earlier publications.

Schmidt and Davis (1941), Fieldbook of snakes:256) give the range of *T. s. sackeni* as "Florida and the adjacent coastal regions, from Charleston, South Carolina, west to the Misissippi River." Schmidt (1953, A check list of North American amphibians and reptiles: 174) lists its range as "Florida, westward in the Gulf Coastal plain through Alabama to Mississippi." Wright and Wright (*op. cit.*:829) quote Allen (1932, Amer. Mus. Nov., 524:16) regarding *T. s. proximus*, but ignore his Harrison Co. records of both *proximus* and *T. s. sauritus*, and they do not recognize the Jackson Co. records of *T. s. sirtalis* [=*T. s. sauritus*] in Smith and List (1955, Amer. Midl. Nat., 53:123). Cook (1943, Snakes of Mississippi, Miss. State Game and Fish Comm. Survey Bull.:68-69) records *sauritus* from the following counties of southern Mississippi: Forrest (3), Harrison (1), Hancock (1), Pearl River (5), Stone (5), Jones (4), Pike (15), Lincoln (1), and Wilkinson (1). Brimley (1910, Copeia, 28:9-18) reports "*sackenii*" from Hancock Co. The Wrights do not include any of these records.

I have at hand 61 specimens of *Thamnophis sauritus* from the

area in which, according to the Wrights, it does not occur. The bulk of this material (52 specimens) is *s. sauritus;* four from Hancock Co. and one from west of the Pearl R. in St. Tammany Par., Louisiana, are closer to *proximus,* having parietal spots and 8 supralabials; three from Hancock Co. and one from Harrison Co. have parietal spots (as in *proximus*) and 7 supralabials (as in *s. sauritus*). One from Washington Par., Louisiana, and one from Mobile Co., Alabama, agree with the description of *s. sauritus.*

All Mississippi snakes seen have three well-defined, complete light stripes; lateral stripes are invariably on the third and fourth rows. Most have 7 supralabials; an occasional example from Forrest Co. has 8, although specimens having more than 7 are more common in Hancock Co., suggesting the influence of *proximus.* Snakes from extreme southeastern Stone Co. and Jackson Co., Mississippi, and from Mobile, Baldwin, and Escambia Cos., Alabama, have 7 supralabials. Since the mid-dorsal stripe in *sackeni* is either reduced or absent and there are 8 supralabials, the range of this form may be limited to exclude Mississippi. The genetic influence of *sackeni* is apparent in Mississippi only in the slightly higher ratio of tail length/total length found in Jackson Co. specimens.

The number of caudals falls within the reported limits of *s. sauritus;* the count is highest toward Alabama on the coast, and lowest in Hancock Co.

The venter is usually immaculate slate gray, sometimes with slightly darker mottlings; chin and throat are pale yellow, and supralabials are usually the same as the venter, rarely pale yellow, sometimes both gray and yellow. The regular dark markings seen in *sirtalis* of this area do not occur.

Summary: The presence of *T. s. sauritus* in southern Mississippi is verified. The influence of *T. s. proximus* is indicated in Hancock Co. The range of *T. s. sackeni* is restricted to exclude Mississippi.—J. William Cliburn, *Department of Biology, Mississippi Southern College, Hattiesburg.*

NOTES ON THE EGGS AND YOUNG OF *EUMECES CALLICEPHALUS* BOCOURT.—In view of the paucity of information on the natural history of the Mountain Skink, *Eumeces callicephalus,* it is thought that the following notes on a female and eggs from Jalisco, Mexico, may be of interest.

The specimen was collected on August 14, 1960, 38.2 miles

northwest of Guadalajara, on Mexican Highway 15. She was coiled around three eggs in a small depression beneath a rock on a grassy road shoulder. The eggs measured, to the nearest mm, 7×6, 7×6 and 7×5.

The lizard and eggs were placed in a can filled with dampened, dead grass. She immediately gathered the eggs together and coiled about them. She stayed around the eggs for the remainder of the two-week trip, moving only occasionally to shift the eggs' position, apparently in an effort to maintain a correct moisture balance. Later, she was placed in a small terrarium with more dampened, dead grass and again coiled about the eggs.

One of the eggs hatched on or about September 1, 1960, but the young lizard could not be found. As the cage was well covered, and the female appeared distinctly fatter, we assume she ate the hatchling. Although offered small insects regularly she had previously refused to eat.

The two remaining eggs hatched on September 5. The young were patterned similar to the adult but much brighter. They measured 54 and 56 mm, total length, with tail lengths 31 and 32 mm respectively. Both young and the female were typical of the Mexican populations of this species in the possession of a postnasal on each side (Smith, 1946, *Handbook of Lizards*: 360). In contrast to this same author's statement (*loc. cit.*:358), "Limbs rather weak, not touching when adpressed, even in young specimens," the adpressed limbs of both young overlap by 7 to 8 scale lengths. The adpressed limbs of the female lack 6 scale lengths of touching.

The head of the young lizard is black to behind the ears except for four orange stripes. The dorso-lateral stripes begin on the anterior supraoculars and run posteriorly, becoming yellow just anterior to the shoulders and fading just anterior to the groin. The median pair begins on the rostral, converging at the posterior margin of the parietals, and extending as a single yellowish stripe posterior to the shoulders where it fades. The lateral stripes, cream in color, pass through the supralabials, the ear, over the insertion of the arm, and then posterior to the groin. Below the lateral stripes the sides are black, blending ventrally into the bluish-green venter. Between the lateral and dorso-lateral stripes the sides are black. The dorsum is a brownish bronze, somewhat lighter posteriorly. The tail is bright blue, slightly greenish at the base. The chin and throat of the largest hatchling are pale irridescent green and of the smallest, cream. The young are now in the herpetological collection of the Department of Biology, University of Florida.—HOWARD CAMPBELL AND ROBERT S. SIMMONS, *420 N. Milton Avenue and 1305 Light Street, Baltimore, Maryland.*

FUNCTION OF THE CHOANAL RAKERS OF THE GREEN SEA TURTLE.—*Chelonia mydas*, the green sea turtle, is unique among turtles, if not among vertebrates as a whole, in having a series of long, corneous, papilla-like rakers arising from the lateral margin of and extending tinelike across each slitlike choana. Parsons (1958, Breviora (85):1-5, pls. 1-2) reviewed the literature on these structures, established that they are absent in juveniles and gradually increase in number to maturity with a variation in adults of 10-14, reported their histology, and analyzed various theories of function. Their histology eliminates any significant sensory role, and Parsons was reluctant to admit that they were correlated with food habits. Resignedly he concluded "they must serve to prevent the contents of the mouth from entering the nasal cavities; whether or not this is their primary function cannot be stated."

In exploring possible correlation with diet, Parsons pointed out that although all sea turtles are omnivorous, "*Chelonia* in particular is primarily herbivorous;" that according to Deraniyagala the "stomach contents are never in a finely divided condition but appear to be 'bolted' entire;" and that although "other chelonids tend to break up their food more" it does not appear likely that a fragment of a mollusc shell or other animal matter would be less injurious than "an unchewed piece of alga." On the other hand, possibly the distinctive strainer-like choanal structure of *Chelonia* is correlated with a distinctive behavior whereby the choanae are exploited specifically as strainers—a function that would be evident if for example the tongue were consistently pressed against the roof of the mouth in manipulation of food and preparation of it for swallowing. Such a habit would be likely to develop especially if the food consists of soft plant matter from which excess water could readily be strained by pressure of the tongue. Since *Chelonia* is more herbivorous than any other sea turtles a reasonable possibility exists that the choanal rakers and a unique (among sea turtles) compressive role of the tongue evolved in adaptation to reliance primarily upon a vegetarian diet. The validity of this hypothesis can be tested only by observations on live animals and possibly by meticulous comparative myological studies. Of some support are the facts that young *Chelonia* are carnivorous and at the same time have few and poorly developed rakers; they are absent or functionless rudiments in hatchlings. Development of the rakers is seemingly correlated rather closely with shift from a carnivorous to an herbivorous diet.

Parsons referred to these structures as choanal papillae. They are here termed choanal rakers in deference to their parallelism both in gross structure and function to the gill rakers of fishes.—HOBART M. SMITH, *Department of Zoology and Museum of Natural History, University of Illinois, Urbana, Illinois.*

ADDITIONAL RECORDS OF *FICIMIA CANA* FROM MEXICO AND TEXAS.—The western hook-nosed snake, *Ficimia cana* Cope, has remained one of the rarest of North American snakes notwithstanding intensive collecting activity in parts of its range. Smith and Taylor (1941, Journ. Wash. Acad. Sci. 31:365-368) reviewed the species on the basis of seven specimens and to the present time records of only 24 specimens have been publishd.

In the United States, *F. cana* is known to range from the Santa Rita Mountains of southeastern Arizona to the Edwards Plateau of western Texas. Despite this extensive latitudinal range along the Mexican border, only two records have been available from Mexico. Smith (1944, Zool. Ser. Field Mus. Nat. Hist. 29:8, p. 139) reported a specimen from Galeana, Nuevo Leon and a snake from near Colonia Juarez, Chihuahua was reported by Tanner and Robinson (1960, Herpetoligica 16:70).

The collections of the University of Colorado Museum contain a specimen of *Ficimia cana* (UCM 14150) from El Calabazal, Zacatecas, Mexico. This locality is near the Durango border on the highway between the cities of Zacatecas and Durango. The snake, a male, was collected on 30 March, 1953 by William Creighton. It has 17-17 scale rows, 127 ventrals, 31 caudals, 33 blotches on the body, 9 blotches on the tail and measures 234 mm. total length. Smith (op. cit.) mentioned that the specimen from Galeana had a lower number of ventral scales and a higher number of body blotches than had been known for the species. The El Calabazal snake has a low ventral count also but the number of body blotches is well within the observed limits of variation. This record extends the known range of *Ficimia cana* approximately 250 miles to the southwest.

A second specimen (UCM 14733) provides an additional record for an area which has produced several specimens of this rare snake. This male snake was collected on 7 June, 1959, four miles south of Basin Junction, Big Bend National Park, Brewster County, Texas by T. Paul Maslin. It has 17-17 scale rows, 135 ventrals, 35 caudals, 31 body blotches and 9 tail blotches.

My thanks are due Dr. T. Paul Maslin for permission to report on these specimens and for assistance in the preparation of the manuscript.—CLARENCE J. MCCOY, JR., *University of Colorado Museum, Boulder.*

NEW CENTRAL AMERICAN RECORDS FOR *RHINOPHRYNUS DORSALIS*.—This species, although widely distributed in México, is unknown in much of Central America. The following records therefore constitute an addition to our knowledge of its geographical distribution.

On June 24, 1960, a calling male was captured in a rain-filled, temporary pool near the buildings of the Instituto Tropical de Investigaciones Cientificas, San Salvador, Departmento San Salvador, El Salvador, 670 meters. Several other individuals were heard calling from the same pool. Three nights later, in a heavy rain, seven more adult males were obtained from the same pool which was about one meter in maximum depth and formed after heavy rains in a low area of a pasture. Other amphibians calling at this locality were *Bufo coccifer, B. marinus, Engystomops pustulosus, Hyla staufferi, Smilisca baudini,* and *Hypopachus championi.* The specimens (KU 60088-60094) range in size from 54.7 to 64.1 mm.

On August 3, 7, and 11, 1960, twenty-four immature specimens (TCWC 15715-15736 and two uncatalogued) were collected from the Stewart Brothers' ranch, Hacienda Mojica, 3 mi. S and 10 mi. W of Las Cañas, Guanacaste, Province, Costa Rica, elevation 3-4 meters. These specimens were found under the tall trees that border the Río Tenorio in the thorn forest and savanna lowlands that occupy much of Guanacaste. Twenty-three of the specimens were found under logs in association with *Hypopachus variolosus.* They range in size from 22.0 to 31.0 mm.; some are recently metamorphosed.

Dr. L. C. Stuart (personal comm.) has tadpoles of *Rhinophrynus* collected at Hacienda Casa Blanca, about 6 km. S of Retalhuleu, Departmento Retalhuleu, Guatemala. Previously this was the southernmost record for the species. Our records extend the known range of *Rhinophrynus dorsalis* approximately 875 kilometers (710 miles) south along the Pacific coastal lowlands.

We wish to thank Dr. William E. Duellman for criticizing the manuscript and making helpful suggestions, Dr. L. C. Stuart for supplying information on the locality of Guatemalan specimens, Mr. Dilford C. Carter for his aid in the collecting, Texas A and M College for financial assistance, and the staff of the Instituto Tropical de Investigaciones Cientificas for aid and cooperation.—Craig E. Nelson and Dale L. Hoyt, *Museum of Natural History, University of Kansas, Lawrence, Kansas.*

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